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ABSTRACT

The project PARK-IT! represents a unique partnership between a public elementary school and a city park in which students and teachers utilize a small naturalized area of the park as a Land Laboratory, and in return become its stewards. The project also includes this curriculum activity guide which can assist teachers in using the Land Lab with students in grades 4-6. The guide begins with an explanation of the importance of a land laboratory, guidelines for taking students outside, and preliminary activities to prepare for going to the site. Activities are grouped by such subject areas as soil, water, plants and animals. Activities address such concepts as composting, role of earthworms in soil production, water in the atmosphere, pollination, seed dispersal, plant community, and succession. Students will conduct a census of invertebrates and explore feeding behavior of spiders as part of field observation activities. The activities include journal questions and extensions. The guidebook includes a summary chart of activities which contains an activity overview, purpose, science skills involved, and learning outcomes keyed to fourth and sixth grade proficiency tests. (PVD)

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DEPARTMENT OF
NATURAL RESOURCES
CITY OF TOLEDO

OEEF
OHIO ENVIRONMENTAL EDUCATION FUND

PARK-IT!

Elementary School Land Laboratories in Toledo City Parks

Curriculum Activity Guide
Grades 4 - 6

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by

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Illustrated by
Dennis M. Garvin

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This Curriculum Activity Guide is dedicated to all educators who strive to keep science in the field and nature in science.

Special thanks to all the elementary teachers of Toledo Public Schools who edited the draft of this resource and to the teachers and administrators who participated in the five "pilot" PARK-IT schools.

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• • INTRODUCTION • •

Welcome to PARK-IT!: Elementary School Land Laboratories in Toledo City Parks! This project is jointly administered by the City of Toledo, Division of Forestry and Open Space Planning and the Toledo Public Schools and is funded by the City of Toledo and grants from the Ohio Environmental Education Fund and the Toledo Urban Forestry Commission. PARK-IT! represents a unique partnership between a public elementary school and a City Park in which students and teachers utilize a small (1/2- to 1-acre) naturalized area of the park as a Land Laboratory and, in return, become its stewards. The project also includes this Curriculum Activity Guide which will assist teachers in using the Land Lab with their students.

Why A Land Laboratory?

Using a natural area in a park or a schoolyard as a Land Laboratory is one of the easiest and most exciting ways to implement Ohio's Model Competency-Based Science Program. The Program, which defines basic scientific literacy as "the capacity of a person to be able to ask questions, collect information and make evidence-based decisions about scientific and technical issues in their [sic] own life", aims to promote scientific literacy through hands-on, inquiry-based learning which involves students working in cooperative groups (Cantrell and Barron, 1994). A PARK-IT! Land Lab accomplishes this on two levels: (1) through the guided inquiries outlined in this Activity Guide and (2) through the inquiry involved in managing the Land Lab as a natural area.

There is little doubt that one of the most important scientific issues that students will confront in their lives will be the health of the environment. The environment provides the basic needs of all living things and is a worthy focus of this Activity Guide as well as science education in general. By using inquiry to discover how soil,.water, plants and animals interact and depend on one another, students will be better prepared to make decisions regarding our natural resources in the future.

Although life science and earth science are the core subject areas examined in this Activity Guide, skills from other subject areas, including language arts, mathematics, social studies and the arts, are incorporated whenever possible. As you become more comfortable teaching your class in an outdoor setting, consider adapting some of your indoor lessons in all subject areas for use outside!

Taking Your Students Outside

Leaving the controlled environment of the classroom for the great unknown of the outdoors is uncomfortable for some teachers. It is hard to imagine that a scenario which appears to invite chaos can engage the students in a way that is difficult to replicate in a classroom! By following a few simple guidelines, you can ensure that your trip to the Land Lab results in a positive learning experience for you and your students (Johnson, 1985):

1. **Establish your rules before going outside.** Be certain that your students understand what is expected of them. They need to know what they will be doing and the time frame in which they will be allowed to do it. However, do not expect the level of order that you can maintain in the classroom. It is important to permit some "controlled chaos" so that your students can explore and improve their capacity to work independently with limited distraction.

2. **Be certain that your students are dressed properly for their time in the field.** Successful field experiences can take place in all kinds of weather if everyone concerned is warm and dry. When working in tall grass or forested areas, it is a good idea to wear long pants, socks and sturdy shoes regardless of the season. Long sleeves may also be necessary if any of the children are sensitive to contact with grasses or need additional protection from the sun. Have your students wear hats, sunscreen and insect repellent if you plan to be outside for an extended period or in Spring or Autumn when sun and insects are troublesome. Winter experiences require layers of clothing, a warm coat, a hat, gloves or mittens, and boots. If possible, inform your students of a field experience at least one day in advance so that they can come to school dressed appropriately.

3. **Be sure that your students have all of the necessary equipment.** Equipment will vary depending on the purpose of your field trip, but a clipboard with paper and pencil for writing, drawing or collecting data and a magnifying lens for exploring are standard. (See the Making Your Equipment section of the Introduction for instructions on how to make an inexpensive clipboard.) If enough students have knapsacks that they can wear, encourage them to carry their equipment on their backs to keep their hands free.

4. **Consider the physical comfort of your students and try to avoid unnecessary distractions, especially when lecturing or leading a discussion.** If you will be talking for longer than a few minutes, find a dry, comfortable place for the children to sit. The fence surrounding your Land Lab has been designed to support their weight and can be used for this purpose. Use shade on a hot day, and avoid having your students sit where the sun will be in their eyes. Keep your eyes open for potential hazards, such as ant colonies and poison ivy patches. If something more exciting than your discussion is happening in the park, you may want to save your discussion for the classroom or another time!

5. **Set clear boundaries before you turn your students loose to work or explore**. Describe verbally and point out visually the landmarks which outline the portion of the park which the children will be allowed to use. Walk the boundaries as a class if your students would find this helpful.

6. **Divide your students into working groups, and assign roles or tasks within each group to facilitate cooperative learning.** Roles will depend on the type of Activity that you have assigned but may include such titles as Coach or Leader, Recorder, Equipment Steward and Measurement Taker. It is important that the students have an opportunity to try a variety of roles and that they are not excluded from being actively involved in the hands-on Activity by what they have been assigned to do. With a little practice, older students will be able to organize their own group work in this way.

7. **Enlist the assistance of an older class or adult volunteers if an Activity seems difficult to supervise**. The extra pairs of eyes and hands can provide your students with the guidance necessary to ensure their success. Older students will also benefit from the opportunity to assume a leadership role.

8. **Seize the teachable moment. Be flexible with your lesson, and allow your students' discoveries to become a part of it, even if they do not directly relate to the topic at hand**. A praying mantis dropping in on your plant lesson could be the most memorable contribution to your students' science education that day. Use these unexpected events to their advantage.

9. **Do not be afraid to say "I don't know" when a student presents you with a mystery object or asks you a question**. The process of using your field guide library to find an answer together will be a valuable lesson for you and your students. Older students who have been oriented to the use of field guides will also benefit from the magic words, "Look it up!"

Making Your Equipment

Many teachers may be discouraged by the lack of equipment available to them for teaching science. Consequently, an apparent need for more specialized equipment can seem an insurmountable obstacle to taking your class outside. Do not let a lack of equipment discourage you. Scientific equipment does not have to be state-of-the-art. With a little creativity, you can improvise functional equipment which is both practical and inexpensive.

In most of the activities outlined in this Activity Guide, your students will be asked to make and use their own tools. Building a working model of a weather instrument or a composter has the important benefit of enabling your students to understand how the tool functions. The process exercises problem-solving skills which may eventually make it possible for your students to design their own tools. In addition, most of the projects in the Activity Guide reuse materials which would otherwise be thrown away or recycled, making them economical and environmentally sound.

As previously mentioned, clipboards and pencils are standard issue when your class will be writing, drawing or collecting data outdoors. Because the office supply variety of clipboard can be pretty expensive, you may want to consider beginning your students' tool making careers by having them build their own.

PRE-ACTIVITY #1:

Making A Clipboard

MATERIALS

For The Class
- Pencil
- Ruler
- Utility knife
- Scissors
- Permanent marker

For Each Student
- 23 cm X 30 cm (9" X 12") piece of cardboard
- #64 (3-1/2" X 1/4") rubber band
- 66 cm (26") piece of string or yarn
- Pencil
- Glue

Prepwork

Have your students bring in heavy corrugated cardboard from home until you have collected enough for one 23 cm X 30 cm (9" X 12") piece per student. Using the utility knife, cut the cardboard into 23 cm X 30 cm (9" X 12") pieces. Using the tip of the utility knife, poke a small hole for the string or yarn that you will be using in the corner of each piece of cardboard. The hole should be located approximately 2.5 cm (1") from the sides. Cut the string or yarn into 66-cm (26-inch) lengths, enough for one per student. Gather all other necessary materials.

PROCEDURE

1. Distribute a 23 cm X 30 cm (9" X 12") piece of cardboard, a rubber band, a 66-cm (26-inch) length of string or yarn, a pencil and glue to each student. Have each student orient his or her cardboard so that the hole which you poked is in the bottom right corner for a right-hander or the bottom left corner for a left-hander. Write each student's name across the bottom of his or her piece of cardboard with permanent marker.

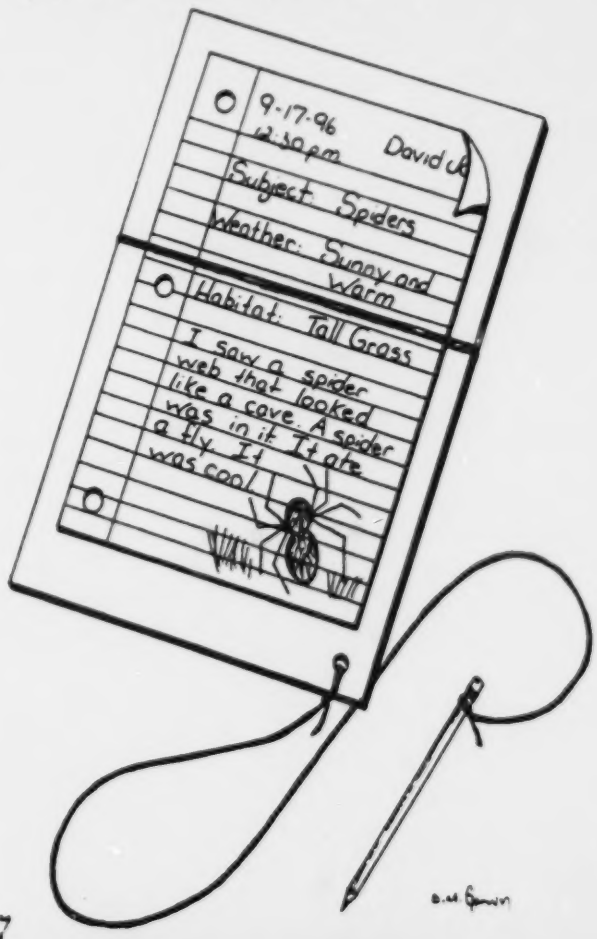
2. Have the students tie one end of their strings through the holes in their pieces of cardboard. Have them tie the other end of their strings to their pencils just above the erasers. Wrapping the string around the pencil twice before tying it and anchoring it with glue will prevent the string from sliding off the pencil when the clipboard is in use.

3. Have the students wrap the rubber bands around their clipboards. The rubber band will serve to hold a paper or Data Sheet in place.

4. Have the students tuck their pencils under their rubber bands for storage. Collect the clipboards for storage in a centralized location, or have your students store them in their desks.

• • •

Another standard piece of equipment which you should prepare for your use before using the Land Lab is a collection of marking stakes. Marking stakes can be used for a variety of purposes, including marking planting sites, setting working boundaries for your students and making other classes aware of a study area. You can make your own by cutting furring strips or other similar scrap lumber into 30-cm (12-inch) lengths and painting the top of each stake with fluorescent paint to increase its visibility. Using an angled cut to create a point on the bottom of the stake makes it much easier to drive into the ground. You should prepare one to two dozen stakes to start.


9-17-96
12:30 pm
David
Subject: Spiders
Weather: Sunny and Warm
Habitat: Tall Grass
I saw a spider web that looked like a cave. A spider was in it. It ate a fly. It was cool.

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Finally, to facilitate the making of tools and maintenance of your Land Lab, consider purchasing or borrowing a hammer and encouraging your students to bring in "throwaways" from home for as long as available storage space allows. The hammer can be used for driving marking stakes and for simple maintenance and construction projects. The on-going collection of throwaways could include gallon milk jugs for carrying water; 5-gallon laundry soap, spackle and pickle buckets for carrying mulch and equipment; and heavy corrugated cardboard, scrap lumber, 2-liter pop bottles, quart milk cartons and half-gallon juice cans for tool making. End rolls of newsprint can be obtained free-of-charge from the Education Coordinator at The Toledo Blade. By pooling your resources with those of other classes, you will easily realize the goal of having adequate equipment for teaching science in your Land Lab.

Respecting Habitat And Inhabitants

In creating a PARK-IT! Land Lab in the park adjoining your school, the City of Toledo and the Toledo Public Schools have allowed a new home for wildlife to grow. Our actions have extended an invitation to animals which utilize the type of habitat provided by the Land Lab to take up residence. With the invitation comes a responsibility to respect the habitat and the animals that will come to live in it. It is important to remind your students of this and to set an example when using the Land Lab.

1. **Use dropped leaves, fruit and flowers for your studies whenever possible.** When you are finished, encourage your students to return these things to the places where they were found, recognizing the importance of dead plants and animals to the soil and the circle of life in general. If you must use part of a living plant, take only what you need (one leaf, one twig) and remove the part with pruning shears or a similar tool instead of tearing it off. The clean cut minimizes damage to the plant's tissues. Return whatever you use to the Land Lab when you are finished with it.

2. **Teach your students to observe all animals from a safe distance, a distance at which they are not perceived as a threat by the animals.** This will enable them to observe the animals' normal behavior and not just behavior based on fear. For instructions on determining a safe distance from which to observe animals, see the Flight Distance Activity for grades K-1.

3. **Never disturb a nest.** Frequent visitation of an animal home constitutes harassment and can interfere with the inhabitants' efforts to feed or rear their young.

4. **Do your homework before allowing your students to handle any wildlife, including insects, earthworms and pill bugs.** Consult a resource which outlines humane handling and care of the species of interest such as Animals Alive!: An Ecological Guide to Animal Activities by Dennis Holley. Be sure to release the animals at the exact location where they were found and at a time when they will not be hindered by inclement weather or lack of food. Your example will form the basis of your students' future interactions with habitat and its wild inhabitants.

Getting To Know Your Land Lab

Your PARK-IT! Land Lab consists of one-half to one acre of City Park land enclosed by a split rail fence. The perimeter established by the fence is rectangular or square in shape, and the fence posts are set square to one another so that the posts can be labeled with x coordinates (letters) and y coordinates (numbers) on an x-y axis. These coordinates can be used by you and your students to locate planting sites and study areas and to compile a base map of the Land Lab.

Compiling a base map is an excellent way to become familiar with the contents of your Land Lab. By placing a large map of the Land Lab on a bulletin board in your classroom, you will be able to orient your students to areas in which you will be working. The map could be used to keep an accurate record of changes in the Land Lab as they occur. It would also be advantageous to create a master of the base map to photocopy for your students to include in their journals or to prepare an overhead transparency.

To begin mapping, you and your students will need to take some measurements. Measuring can be done with a tape measure or by providing each student with his or her own measuring tool: the length of a pace.

PRE-ACTIVITY #2:

Determining The Length Of A Pace

Once you and your students have determined the length of each person's pace, you can use pacing to take the measurements necessary to compile a base map of the Land Lab.

MATERIALS

For The Class
- Tape measure or other measuring device
- Marking stakes (2)

For Each Pair Of Students
- Clipboard with pencil
- Scrap paper for calculations

PROCEDURE

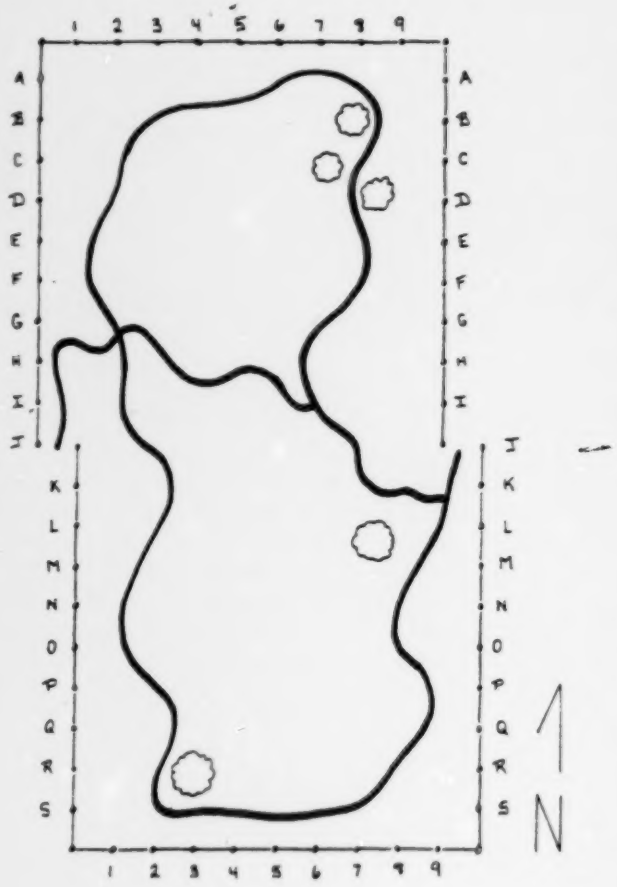
1. Measure 30 meters (100 feet) with the tape measure or other measuring device, and mark off the distance with marking stakes.

2. Have your students line up behind one of the stakes facing the other. Explain to them that they will be walking the distance marked one at a time, beginning with their left feet and counting the number of times that their right feet hit the ground. A pace is equivalent to two steps. At your instruction, have each student count the number of paces required to walk the distance. Encourage your students to walk as normally as possible and to try not to make their steps bigger or smaller.

3. Have each student repeat the procedure three times and then calculate the average number of paces required to walk the distance. This is accomplished by adding the results of the three trials together and dividing by three.

4. Divide or have your students divide 30 m (100') by the average number of paces required to cover the distance to yield the length of one of their paces.

4. Have the students practice measuring unknown distances. Have them walk the distances while counting their paces and then multiply the number of paces required to cover each distance by the length of one pace. The students can also mark off a desired distance by dividing the distance by the length of one pace and walking the



PRE-ACTIVITY #3:

Compiling A Base Map

MATERIALS

For The Class

- Measuring tape or other measuring device (if pacing will not be used)
- Clipboard with pencil
- Scrap paper for recording measurements
- Large sheet of newsprint
- Meter stick or yardstick
- Permanent marker

For Each Student Or Group Of Students

- Clipboard with pencil
- Blank sheet of paper or grid sheet
- Ruler
- Crayons or markers for coloring, if desired

PROCEDURE

1. Have your students measure the perimeter of the Land Lab and the distance between the fence posts or points of intersection of the x and y coordinates. Measuring can be done with a tape measure or by pacing. Record the measurements on your sheet of scrap paper. Return to the classroom.

2. Establish a scale for the map A scale can be determined by selecting a desired size for the finished map and dividing the length of one of its sides by the actual length of that side in the Land Lab. For a large sheet of newsprint 2 meters in length, 2 meters may be divided by the length of the side of the Land Lab (64 meters) to yield a scale of 0.03125 meters or 3 centimeters to 1 meter of Land Lab.

$$\frac{\text{2 meters (size of the map)}}{\text{64 meters (size of the Land Lab)}} =$$

$$\frac{0.03125 \text{ meter}}{1 \text{ meter}} =$$

$$\frac{3 \text{ centimeters}}{1 \text{meter}} \text{ or } \left[\frac{1 \text{ inch}}{3 \text{ feet}}\right]$$

3. For a sheet of typing paper 28 centimeters in length, 0.28 meter may be divided by the length of the side of the Land Lab (64 meters) to yield a scale of 0.004 meter or 0.4 centimeter to 1 meter of Land Lab. Multiplying through by 5 yields the scale in whole numbers: 2 centimeters to 5 meters of Land Lab.

$$\frac{\text{0.28 meter (size of the map)}}{\text{64 meters (size of the Land Lab)}} =$$

$$\frac{0.004 \text{ meter}}{1 \text{ meter}} =$$

$$\frac{0.4 \text{ centimeter}}{1 \text{ meter}} \times \frac{5}{5} =$$

$$\frac{2 \text{ centimeters}}{5 \text{ meters}} \text{ or } \left[\frac{1 \text{ inch}}{15 \text{ feet}}\right]$$

4. Return to the Land Lab with grids and clipboards with pencils to add details to the map. The procedure will vary according to the abilities of the students. Younger students can draw landmarks such as trees, stumps and trails as they appear within the rectangle or square. Older students can identify the x and y coordinates for each landmark and plot them on the grid. For an even more accurate map, have the students use the fence posts, marking stakes and string to construct a grid over each section of the Land Lab and corresponding square on the map. Encourage the students to label the map in as much detail as possible.

5. Upon returning to the classroom, allow your students to color their maps, if desired. Instruct them to include themaps in their personal science journals, if applicable.

• • •

Regardless of the method used, this mapping exercise will sharpen your students' math skills and introduce them to the physical layout of the Land Lab. To draw their attention to details that might not appear on the map, design and conduct a scavenger hunt with your students.

PRE-ACTIVITY #4:

Conducting A Scavenger Hunt

MATERIALS

For Each Student
- Clipboard with pencil
- Copy of brainstormed scavenger hunt checklist
- Crayons for coloring, if desired

PROCEDURE

1. Together with your students, brainstorm a list of scavenger hunt items that they would expect to find in the Land Lab. Write the students' ideas on the chalkboard. You may want to provide rough sketches of the items for younger students.

2. Have each student prepare a checklist of the items listed on the chalkboard using phrases and/or pictures. Checklists which include pictures may be colored, if desired. Distribute clipboards with pencils to your students, and have them attach their checklists to their clipboards. Go to the Land Lab.

3. Establish boundaries for the scavenger hunt, and outline any limits which you wish to place on collecting. Then turn your students loose to find as many of the items as they can. They will truly enjoy this initial unstructured time to explore.

4. Conclude the scavenger hunt by having the students share their findings. Did they find the items that they expected to find? Did they find the unexpected?

• • •

Caring For Your Land Lab

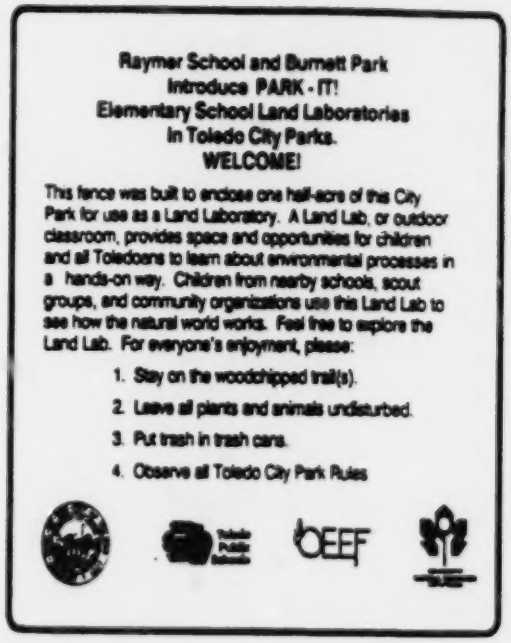
Your Land Lab encompasses a significant portion of a City Park. Like any City Park facility, it is for use by the citizens of Toledo and is therefore subject to wear and tear.

Each PARK-IT! Land Lab has signs posted near its entrances. These signs describe the PARK-IT! project, what a Land Lab is and how it is used and may be enjoyed. The signs also list guidelines for users to bear in mind. A sample of such a sign is shown below for your reference.

If you and/or your students notice fence rails are down, please return them to their original position. If fence rails or fence posts are broken or missing, please call the Naturalist staff at the Ottawa Park Nature Education Center at (419)936-2876. If vandalism is witnessed, please call 911 immediately and then inform the Ottawa Park Nature Education Center of the incident.

Trees which have been subject to vandalism or storm damage should also be brought to the attention of the Ottawa Park Nature Education Center. A dead tree may not be replaced, but an injured tree may be saved through trimming by the Naturalist staff.

The greatest threat to the trees of your Land Lab is insufficient and improper watering. Trees, especially young, newly planted ones, require a lot of water: as much as 10 gallons per week in the Spring and Summer. Water should be applied slowly. You can ensure sufficient watering at a desirable rate of flow by making watering buckets and instructing your students in their use.


Raymer School and Burnett Park
Introduce PARK-IT!
Elementary School Land Laboratories
In Toledo City Parks.
WELCOME!
This fence was built to enclose one half-acre of this City Park for use as a Land Laboratory. A Land Lab, or outdoor classroom, provides space and opportunities for children and all Toledoans to learn about environmental processes in a hands-on way. Children from nearby schools, scout groups, and community organizations use this Land Lab to see how the natural world works. Feel free to explore the Land Lab. For everyone's enjoyment, please:
1. Stay on the woodchipped trail(s).
2. Leave all plants and animals undisturbed.
3. Put trash in trash cans.
4. Observe all Toledo City Park Rules
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PRE-ACTIVITY #5:

Making And Using Watering Buckets

MATERIALS

For The Class
- 5-gallon plastic bucket (1 per watering bucket)
- Electric drill
- 3/8" drill bit
- gallon milk jug (5 per watering bucket)

PROCEDURE

1. Drill a 1-cm (3/8") hole in the base of each 5-gallon bucket. Your watering bucket is now complete! Fill the gallon milk jugs with water and cap them. Have your students carry the watering bucket or buckets and the milk jugs of water to the Land Lab.

2. Have your students place each watering bucket on the mulch mound over the roots of a subject tree. Have them pour 5 gallons water from the milk jugs into each watering bucket. The water will slowly trickle from the 1-cm (3/8") hole, through the mulch mound and into the ground.

• • •

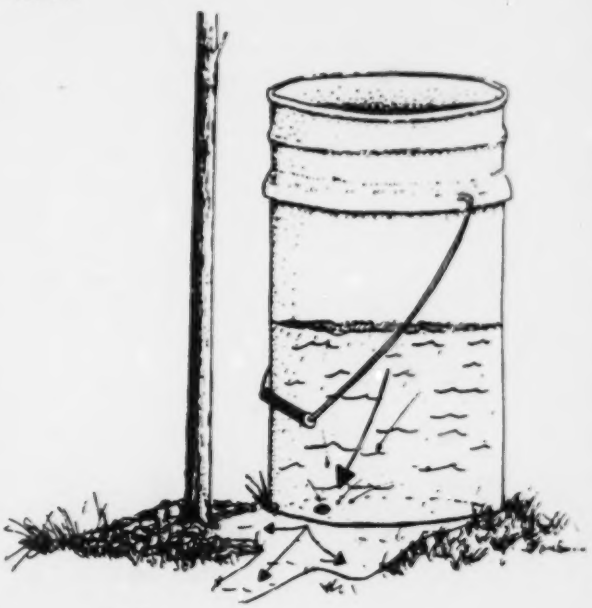
Woodchip mulch is an ideal material to apply on Land Lab trails. The woodchips reduce erosion and prevent plants from growing on the trail. Woodchips are our recommended mulch to place around newly planted trees and shrubs. Mulch prevents grasses and weeds from directly competing with trees for water. It also helps the soil retain water by reducing evaporation. When mulching beneath a tree, make sure the depth of the mulch bed does not exceed 10 centimeters (4 inches).

Woodchips are also an inexpensive way to prepare a planting bed for flowers or other plants which you and your class integrate into your Land Lab. After establishing boundaries of a potential planting bed site, spread a blanket of woodchips 10-15 centimeters (4-6 inches) deep over the area. The woodchips can be applied with 5-gallon buckets. Within a few weeks, the mulch will have killed the vegetation beneath it. Remove the woodchips from the area. Your planting bed is now ready for planting and regular watering. The woodchips which you have removed can be reused for other planting projects. Please call the Ottawa Park Nature Education Center if your Land Lab is in need of woodchips.

Using Your Land Lab

In addition to caring for your Land Lab, you and your students will share the responsibility of compiling a class journal. The class journal is one of the evaluation requirements of the PARK-IT! project. Its contents are left to your discretion but should document your class' use of the Land Lab through student writings, drawings, pictures and Data Sheets. In addition to allowing an outside observer to become familiar with your work in the Land Lab, the class journal will assist you with long-term record keeping. It will allow your current class to compare the results of their studies with those of any previous classes. This opportunity to compare could prove invaluable to your science teaching as the Land Lab grows and changes.

Although they are by no means required, you are also urged to assist your students in preparing personal journals. Like the class journal, the personal journal is probably best organized in a three-ring binder. This format enables your students to divide their journals into sections of handouts, writings, drawings or Data Sheets and to add information gathered in the Land Lab without having to take the entire journal outside. Encourage your students to decorate their journals, and set aside time during the course of each Activity to use them in some way. The students can use writing to focus their thoughts, to keep track of their learning, to plan how they will solve a problem, to take notes and comment on their reading and to reflect on their experiences (Hogan, 1994). If you or your students have trouble getting started or using the journal on a regular basis, you can consult the JOURNAL QUESTIONS section near the end of each Activity in this Activity Guide for a suggested journal entry which will reinforce the lesson.



As stewards of a PARK-IT! Land Lab, the role of your school's faculty, staff and students extends beyond basic maintenance and record keeping. You will all have a say in what the natural area actually becomes. By planting seeds and encouraging certain types of growth, you will be partners with the natural process of succession in creating a specific kind or kinds of habitat. Although management decisions will ultimately be made by your school's designated PARK-IT! Committee, you and your students should engage in on-going discussion about what you would like to see happen to the Land Lab. Submit your ideas to the Committee for consideration. If your suggestions meet with approval, encourage your students to follow through with them. Before initiating any planting project or on-going study, discuss the location with the PARK-IT! Committee to avoid disturbing the projects of other classes.

Your final responsibility as a steward of your PARK-IT! Land Lab is to utilize the Land Lab for the purpose for which it is intended: to provide quality hands-on science experiences for your students. You may have dozens of ideas on how to implement this or feel a little overwhelmed by the thought. This Curriculum Activity Guide was written with both scenarios in mind. It includes 25 activities, eight or nine per grade level grouping (K-1, 2-3 and 4-6). These activities focus on soil, water, plants or animals as they can be observed in the Land Lab and are written in a complete, easy-to-follow format. An explanation of the format follows.

The **TITLE** includes the subject of the lesson and a tongue-in-cheek subtitle for your entertainment.

GRADE LEVEL/TOPIC indicates the grade level grouping for which the Activity was developed and the broad category into which it fits: Soil, Water, Plants or Animals.

TIME REQUIRED/RECOMMENDED SEASON offers an estimate of the time which it will take to complete the Activity and the season of the year during which the Activity is likely to work best. It indicates if the Activity must be done in more than one session or is ongoing.

SCIENCE SKILLS lists those skills involved in the learning and practice of science which are used in the Activity.

KEY WORDS lists vocabulary which may be used to prepare your students for the Activity. These terms are highlighted in the BACKGROUND INFORMATION using bold type.

The **OVERVIEW** summarizes the Activity and indicates the types of learning experiences which are included. It suggests how the time required may be divided among these experiences to aid you in breaking the lesson into shorter segments which accommodate your time allocation for science.

The **PURPOSE** states what the students will do or be able to do as a result of completing the Activity.

MATERIALS provides an itemized list of the materials recommended to carry out the Activity and indicates whether they are needed for the class, for a group of students or for each individual student. The Prepwork section outlines those preparations which you will need to make to get the materials ready for use in the Activity. Improvising is encouraged!

The **BACKGROUND INFORMATION** provides you with some expertise in the subject of the Activity so that you can successfully brief your students prior to their participation in the Activity.

The **BEFORE YOU GO** section details the steps which you will take to prepare your students in the classroom before going outside.

The **PROCEDURE** is the body of the Activity which takes place in or focuses on the Land Lab. It is presented in a step-by-step format.

The **CONCLUSION** outlines a follow-up exercise or exercises for the classroom which provide closure to the Activity.

JOURNAL QUESTIONS suggests a way to use the students' personal journals to reinforce what they have learned from the Activity.

EXTENSIONS offers additional activities which you can use to build on what your students have learned if their interest indicates that they want to know more.

REFERENCES/ADDITIONAL READING lists literature cited and used to compile the Activity and other resources which you may find helpful in teaching your students about the subject matter. Books which are available at the Toledo/Lucas County Public Library are indicated by the initials TLCPL in parentheses. Most other titles may be obtained through inter-library loan.

CHILDREN'S SCIENCE/TRADE BOOKS lists children's literature which may be used in conjunction with the Activity. Books which are available at the Toledo/ Lucas County Public Library are indicated by the initials TLCPL in parentheses.

Some of the activities include Instruction Sheets for making tools, Data Sheets for collecting and recording data and other handouts for student use. Templates are included for most craft projects, and illustrations are found throughout the activities which clarify the text. For an overview of all of the activities in this Activity Guide, including titles, summaries, purposes, science skills and learning outcomes addressed, please consult the chart at the end of the Introduction.

Most of the activities in this Guide are guided inquiries. The explorations and experiments have been designed for you and your students. However, one of the desired outcomes of science learning is for your students to acquire the ability to design and plan their own explorations and experiments. Whenever possible, have your students use the background information which you have discussed with them to make predictions, or hypotheses, which can be tested during the course of the Activity. By highlighting the scientific process in each guided inquiry, you can provide your students with the confidence that they will need to strike out on their own. When they do, the possibilities for using your Land Lab will be endless.

Happy sciencing!

References/Additional Reading

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PARK-IT!
Activity Summary

Title	Overview	Purpose	Science Skills	Learning Outcomes
	This Activity Consists Of ...	**The Students Will ...**		**See Appendix A**
K-1				
Soil Compaction *Puddles Under The Swing Set*	A demonstration of compaction, a field test of soil and a demonstration of how aeration improves soil quality.	Observe that well aerated soil absorbs more water than those soils which are compacted.	Observing, Comparing, Predicting	6,8,11,12,14,15,17
Animal Sign Census *Who Goes There?*	A comparison of the Land Lab and other areas of the park in terms of animal sign.	Identify animal sign and recognize that more sign will be found in the Land Lab.	Observing, Questioning, Record Keeping, Censusing	2,4,6,7,14,16,17
Splatter Testing *Keeping It Together*	A demonstration of erosion and its effects.	Observe the action of water on soil and the ability of vegetation to reduce this effect.	Observing	2,5,6,11,14,15
Soil Content *Sorting It Out*	A demonstration of soil particles, field test of soil and a game.	Be able to distinguish between different sizes of soil particles and predict that the largest ones are the heaviest.	Observing, Predicting, Collecting	1,2,6
Transpiration *Plants Don't Sweat, They Transpire*	A demonstration of water storage in plants, observation of a solar still and a worksheet.	Demonstrate that living plants store water and trace the path of water through a plant.	Observing, Questioning, Model Building	2,6,7,16
Evaporation *Which Way Did It Go?*	A search to find a place in the Land Lab where water will evaporate the most quickly.	Observe that water has three forms and name some factors which influence evaporation.	Observing, Hypothesis Testing, Questioning	2,5,6,7,8,11
Propagation *From Seed To Tree*	An introduction to types of tree seeds; selection and planting of and caring for seeds.	Recognize that fruits contain seeds and plant and properly care for tree seeds.	Observing, Collecting, Record Keeping	1,6,14,16,17
Flight Distance *I Need My Space*	Demonstrations of proximity, field testing of ideas and a game.	Show that animals need space.	Observing, Questioning, Measuring	2,3,5,6,8,12,16,17
Plant Parts *Look, Ma, No Hands!*	Matching game with plants in the classroom and a scavenger hunt in the Land Lab.	Match illustrations of plant parts with plants in the Land Lab, and color those illustrations.	Observing, Record Keeping	2,4,6,7,8,16,17
2-3				
Growth Of Propagated Plants *How Does Your Land Lab Grow?*	An introduction to tree growth, measuring and drawing seedlings in the Land Lab.	Observe characteristics of a growing plant and produce a scale illustration of a plant based on data from the Land Lab.	Observing, Measuring, Mapping, Record Keeping	2,3,6,7,14,16
Soil Permeability *Down the Soil Drain*	Constructing a measuring device, field testing of the device and producing group reports.	Construct and use a measuring device to determine soil permeability and explain how land use effects the ability of soil to absorb water.	Tool Making, Observing, Data Collecting and Recording, Measuring	2,3,5,6,8,14,15,16, 17,18
Common Insects Which Use Plants *Look Who's Been Eating My Land Lab*	Building insect models, looking for insects in the Land Lab and follow-up discussions.	Give examples of insects which use plants and identify insect sign on plants.	Model Building, Observing, Identifying, Record Keeping, Comparing	1,4,8,16,17
Rate of Decomposition of Leaf Species *Now You See It, Now You Don't*	Making leaf rubbings as an aid to identification, building a mulch pile and monitoring the rate of decomposition of leaves from different species of trees.	Identify leaves from five different species of trees, compare and contrast the rates of decomposition of those leaves over the school year.	Observing, Collecting, Identifying, Record Keeping, Mapping	1,4,5,6,8,14,16
Weather Station *Whether We Like It Or Not*	Making and using simple instruments to monitor the weather.	Construct weather-monitoring devices and describe how the water cycle and temperature contribute to daily weather.	Observing, Data Collecting and Recording Record Keeping, Monitoring, Measuring, Tool Making and Use	2,3,5,6,7,8,9,10 12,13,14

Park-It!
Activity Summary, Continued

Title	Overview	Purpose	Science Skills	Learning Outcomes
	This Activity Consists Of ...	**The Students Will ...**		**See Appendix A**
2-3, Continued				
Snow - How It Changes Life for Animals *Snow What If I'm Up To My Tail In Snow?*	Building a snow pile to explore temperature and density of snow.	Describe ways snow influences the behavior of animals and observe and quantify characteristics of snow.	Observing, Collecting and Recording Data	3,6,8,9,11,16 17
Food Preferences of Neighborhood Birds *If You Were The Early Bird, Would You Eat A Worm?*	Establishing a bird feeding station and determining what and where the birds like to eat.	Determine food preferences of birds and use that information to make recommendations for permanent feeders.	Observing, Collecting and Recording Data, Experimental Design, Identifying, Monitoring	2,4,16,17
Native versus Non-Native Plants *Alien Invaders*	Removing dandelions from a plot in the Land Lab and observing the short regeneration time.	Identify physical characteristics shared by non-native plants and use a removal technique to demonstrate how and why they are so successful.	Observing, Censusing, Sampling, Record Keeping, Mapping, Comparing and Contrasting	1,4,5,6,8,14,16,17
4-6				
Water in the Atmosphere *Up In Vapor*	Constructing and using weather instruments.	Compare and predict differences in atmospheric conditions between the Land Lab and a mowed lawn.	Observing, Measuring, Monitoring, Collecting and Recording Data, Predicting, Hypothesis Testing, Tool Making	5,7,8,10,13
Inventory of Worm Castings *This Too Shall Pass*	Constructing a grid to use in a field experiment and the mapping and measuring of worm castings.	Set up, map and inventory plots where they will estimate the soil-making capacity of worms in the Land Lab.	Tool Making, Observing, Sampling, Mapping, Monitoring, Collecting and Recording Data	3,5,12,14,17
Invertebrate Censusing *The Spineless Wonders*	Censusing of invertebrates and a mark-and-recapture study of grasshoppers.	Distinguish between orders of insects construct and use a sweep net to census invertebrate and estimate population size of grasshoppers in the Land Lab.	Sampling, Identifying, Censusing, Collecting and Recording Data, Graphing, Comparing, Analyzing	1,2,3,5,15,17
Spider Observation *Look! It's A Spider, Man!*	Baiting and observing the feeding behavior of funnel spiders, model building and letter writing.	Describe feeding behavior of funnel spiders and record their observations by using a field notebook. Writing a letter and building a model.	Observing, Model Building, Note Taking, Record Keeping	2,3,5,6,10,14,15
Soil Making/Composting *It's A Dirty Job ...*	Construct a pop bottle composter and use it to study the soil-making process.	Identify the components of soil. Make small composters and use the resulting compost in a planting project.	Observing, Collecting, Monitoring, Record Keeping, Predicting, Hypothesis Testing	3,4,5,8,12,13,15 17
Seed Dispersal *I Get Around*	Construct a model of a seed and a device with which pollen and seeds can be trapped.	Identify methods of seed dispersal and design an experiment to allow for the capture of seeds and pollen.	Observing, Collecting and Recording Data, Identifying, Experimental Design	1,3,5,7,10,15
Succession *One Thing Leads To Another*	Setting up a transect and collecting data about plants in the Land Lab.	Use a transect to collect data and contribute to an on-going record of changes in the plants of the Land Lab over time.	Observing, Monitoring, Experimental Design, Measuring, Collecting and Recording Data	3,4,5,10,14,15
Pollination *Sex And The Single Flower*	Construct a model of a flower to attract insect pollinators.	Demonstrate features of a flower through model building and describe the process of pollination and seed formation.	Observation, Collecting and Recording Data, Model Building, Monitoring, Predicting	3,5,10,13,14

Soil Making/Composting

It's A Dirty Job...

GRADE LEVEL/TOPIC: 4-6/Soil

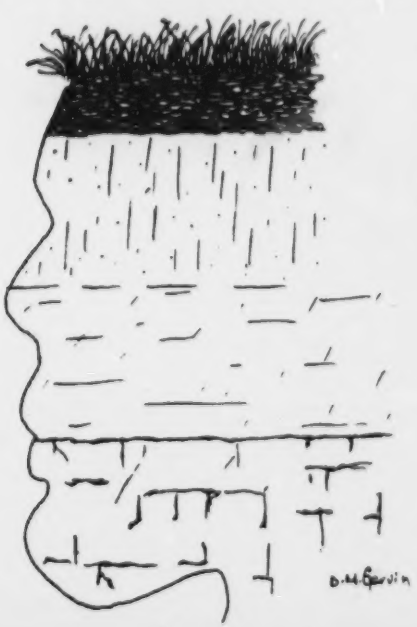
TIME REQUIRED/RECOMMENDED SEASON: Two 45-minute periods initially, then short periods monthly throughout school year/ Autumn through Spring

SCIENCE SKILLS: Observing, Collecting, Monitoring, Record Keeping, Predicting, Hypothesis Testing

KEY WORDS: Composting, Decomposition, Parent Material, Organic, Inorganic, Soil, Glacier, Till, Litter, Thatch, Duff, Humus

OVERVIEW

This Activity explores the organic components of soil and the mechanics of soil formation through the composting of dead leaves, dried grass and wood chips in a pop bottle composter constructed by the students (30-40 minutes). The students will be examining soil and collecting raw materials for composting in the Land Lab (30-40 minutes). They will then assemble and fill the composter and monitor the compost throughout the year (15-20 minutes every two to four weeks). Finally, your class will test compost, soil and a compost/soil mixture as media for growing plants (20-30 minutes over a few weeks). Feel free to break up this Activity into smaller lessons if you wish. If this is your first Activity, please consult the Introduction.



PURPOSE

1. Students will identify and describe the components of soil, including organic and inorganic materials.
2. Students will utilize organic and inorganic materials found in the Land Lab and/or surrounding park to produce compost/soil.
3. Students will describe the process of decomposition.

MATERIALS

For The Class

- Permanent marker
- Exacto or utility knife
- Wooden or metal spoons (4 or more)
- Buckets for collecting rainwater (3)
- Bucket of potting soil or soil from the Land Lab (this is needed next Spring)
- Packet of marigold seeds (this is needed next Spring)

For Each Group Of 2 Students

- 2-liter pop bottles, numbered and without labels (2)
- Scissors
- Push pin
- 10 cm X 10 cm (3"x3") squares of nylon from a pair of panty hose
- Rubber bands (2)
- Clear packaging tape
- Ruler, 1 foot
- Permanent marker
- Rain water (2-4 cups)
- Metal spoon or trowel
- Zip locked bag for organic and inorganic materials
- Gallon milk jug of rain water
- Styrofoam cups (3) (this is needed next Spring)

For Each Student

- Data Sheet for describing decomposition
- Pencil

Prepwork

Have students collect two to four cups of rain water in a bucket and store it in a milk jug prior to beginning this Activity. If this proves difficult, water can be used that has been collected from puddles.

Photocopy a Data Sheet for each student.

Instruct students to bring in two-liter pop bottles from home until you have collected enough for two per pair of students.

a. Peel off the labels; running hot water over the inside of the bottle where the label is attached makes this process easier.

b. Number the pop bottles such that each group of students has a Bottle #1 and a Bottle #2.

c. If desired, measure and mark on each bottle where students will be cutting apart the bottles. You may want to let the students measure and mark their own bottles (see #1 in the instructions). Use the exacto knife to cut a slit in each mark so that the students will be able to insert their scissors and cut the bottles apart.

Gather the remaining materials. The bucket of soil, packet of marigold seeds and styrofoam cups will not be required until Spring.

BACKGROUND INFORMATION

Soil is a constantly changing commodity which is formed as a result of two basic processes: the weathering of **inorganic** (of non-living origin) parent material into particles of sand, silt and clay and the decomposition of plant and animal remains into **organic** (of living origin) materials. Weathering of **parent material**, or bedrock, is primarily a physical and chemical process involving the action of water, such as freezing and thawing, and the action of gases, such as oxidation, on solid rock. (Cvanara, 1985) **Decomposition** is a biological process involving living things, such as bacteria and worms, which break down dead plants and animals and release their nutrients back into the soil.

In Northwest Ohio, two significant events helped to mold the formation of the soil: the advance and retreat of the **glaciers** and the draining of the Great Black Swamp. The scouring action of the glaciers collected a mixture whose particles ranged in size from boulders to clay and were called **till**. This material was deposited throughout our area as the glacier melted back to the north. Decomposition in the Great Black Swamp produced a rich organic muck which became the basis for "a gardening spot" after German immigrants drained the swamp using ditches and tiles. (Stone, 1980)

Because soil is formed from above (remains of living things) and below (bedrock), it develops a layered structure called a soil profile. The nature of the different layers, or horizons, is dependent on the degree of weathering involved. The topmost layer, or A-horizon, contains the most organic materials. These materials are classified based on their degree of decomposition. The top layer is called **litter** and consists of recognizable plant and animal parts. If this layer is composed of dead grass, it is sometimes referred to as **thatch**. The layer beneath it is called **duff** and contains pieces of litter which may be just barely recognizable. Beneath these layers is humus, a dark, nearly decomposed material mixed with soil.

The second horizon from the top, or B-horizon, is generally distinguished from the A-horizon by differences in color and contains materials such as iron, aluminum, clay or calcium carbonate leached from the A-horizon. Most plant activity occurring in the soil takes place in these two horizons. The horizon between the B-horizon and the bedrock is the C-horizon and is composed of less weathered materials. Over time, the upper parts of this horizon are weathered further and become part of the B-horizon (Roth, 1984).

In this Activity, your students will attempt to simulate the formation of soil by collecting both organic and inorganic materials in the Land Lab or park and composting them in a device for this purpose which they have constructed. **Composting** is the biological degradation or breakdown of organic matter by bacteria and fungi, accelerated and improved by human intervention. (Dickson, 1991) Traditionally, composting has been used to recycle agricultural wastes such as food scraps and manure for soil enrichment. However, the fact that the process of decomposition significantly reduces the bulk of the organic material involved has suggested its potential as a means to conserve landfill space. This Activity will demonstrate that some of materials which people consider to be yard waste (dead leaves, cut grass, wood chips) are actually important raw materials in the formation of soil. Eureka!

BEFORE YOU GO

1. Discuss the background material with your students, emphasizing soil origin and development. Describe composting as a soil making process and discuss its benefits.

2. Divide the students into groups of two, and distribute the materials for composter construction (**SEE COMPOSTER INfORMATION SHEET**). Have each team construct a pop bottle composter.

3. When all teams have completed their composters, distribute a metal spoon or trowel and zip locked bag to each group and instruct the students to take their digging implement and their composter with them outside.

PROCEDURE

1. Gather your students near the entrance of the Land Lab. Explain to them that in order to make soil in their composter, they will first need to identify the raw materials. Arrange a meeting time and place and instruct the teams to find a spot to dig in the top soil layer.

2. Allow the students to dig in the soil and identify remnants of inorganic and organic materials that they find. Have them collect examples of what they find in their zip locked bags to share with the class. Meet at the pre-arranged place.

3. Have the teams share the organic and inorganic materials that they have found. Focus their attention on the parent material (rocks) and organic materials classified as yard waste (leaves, grass, woodchips) and designate these four materials as the ones which they will use in their composter.

4. Have each team fill their composter with equal parts of these four materials. The rock/gravel layer should be added first, followed by dead leaves, dried grass and woodchips. Encourage the students to crinkle or grind the leaves and grass before adding them to the composter to facilitate decomposition. Materials should be packed firmly into the composter, but leave about 5 centimeters (2 inches) at the top for air circulation.

5. When all the teams have finished filling their composters, return to the classroom.

6. Have each team mix the materials in their composter thoroughly using their hands or the spoons provided. Instruct them to open the composter and pour approximately one cup of rainwater into the column. Students should then replace the top.

7. Distribute a Data Sheet and a pencil to each student and have them fill out the initial information for their composter. Have students measure the height of the compost inside the composter and write this information on the Data Sheet. Ask students to predict how fast it will take all of the organic material in the composter to decompose. Have them write this information on their Data Sheet. Log Sheets can be kept in student journals, if applicable.

8. Leave the composters for several hours to allow the water to percolate through the column. If no water collects in the bottom, have the students add another cup of water to the column and then additional cups every several hours until about half a cup of water collects in the base. Every few days, instruct the students to pour the "compost tea" from the bottom back through the composter.

9. Set aside time in class every two to four weeks (use a regular interval) for the students to examine the compost and log its progress. Have the students mix the contents of the composter thoroughly and remove a small quantity for examination. Have them describe the compost on their Data Sheet, emphasizing its smell, appearance (particle size and shape), color, feel and its volume compared to the initial volume. Are the different components still distinct? How long does it take for the organic materials to completely decompose? Do the students observe any changes in the inorganic materials (rocks)? Have the students replace their samples of compost and store their Data Sheets in their journals.

CONCLUSION

1. After returning from Spring Break, have the students test their compost as a soil which can support plant life by planting seeds in it. Distribute three styrofoam cups to each team of students. Have them prepare the cups for planting by adding soil from the Land Lab to the first, a mixture of half soil and half compost to the second and compost from their composter to the third. Hand out six marigold seeds to each team and have them plant two seeds in each cup. Instruct the students to water the seeds as needed.

2. Have the students rank the resulting plants in the order of their success in terms of growth. Which of the plants appear to have all of their requirements for growth met? Discuss the results. If desired, have students graph the growth of the marigold seeds over time.

JOURNAL QUESTIONS

Most of the organic materials used to make compost in this Activity are those materials which people remove from their lawns as waste. Since law dictates that lawn waste can no longer be hauled to landfills, what solutions are suggested by your findings?
Design a composter which you feel would handle this quantity of waste.

EXTENSIONS

1. **Compost or Soil?** At what point in the decomposition process are nutrients released and made available for growing plants? Make an additional pop bottle composter and have the students try to plant marigold seeds in samples of the compost every two to four weeks. Determine the stage of the process when the compost is able to support a healthy plant.

2. **Hay Infusion.** If you have access to a microscope, have the students add a handful of dried grass to a jelly jar full of water once a week for several weeks. Make sure that lids are removed and that the jars are carefully marked (Week 1, Week 2, Week 3, etc.). When the first jar has been allowed to sit for at least three weeks, allow the students to examine the water from each jar under a microscope, beginning with the most recently prepared jar, and note the kinds and quantities of organisms which they observe. What is the role of these organisms in composting?

3. **Composting Food Waste**. Have the students build additional composters and use them to compost small amounts (1/2 cup or so) of waste from their lunches. This is another source of garbage which does not necessarily have to go to a landfill. For best results, envelope food waste from plant sources only between layers of soil from the Land Lab. How does this compost compare with that formed from dead leaves, dried grasses and wood chips?

4. **Mini-Landfills.** Much of our garbage is disposed of by burying it beneath a layer of soil in an area called a landfill. Most of it takes much longer than lawn and food waste to decompose. A pop bottle composter can be used as a mini-landfill to observe the rates of decomposition of various types of garbage which your students collect. Have the students bring in small pieces of garbage such as nutshells, potato peels, paper napkins, newspaper strips, plastic baggies, pop tabs and aluminum foil and place them in the composter between layers of soil from the Land Lab. Be certain to keep the column moist and to locate the garbage against the side of the column so that it can be plainly seen and its rate of decomposition, readily observed. What disappears the quickest? What remains unchanged?

5. **Thesaurus Rex.** How many words can your students find or think of to describe the feel, smell and appearance of the compost?

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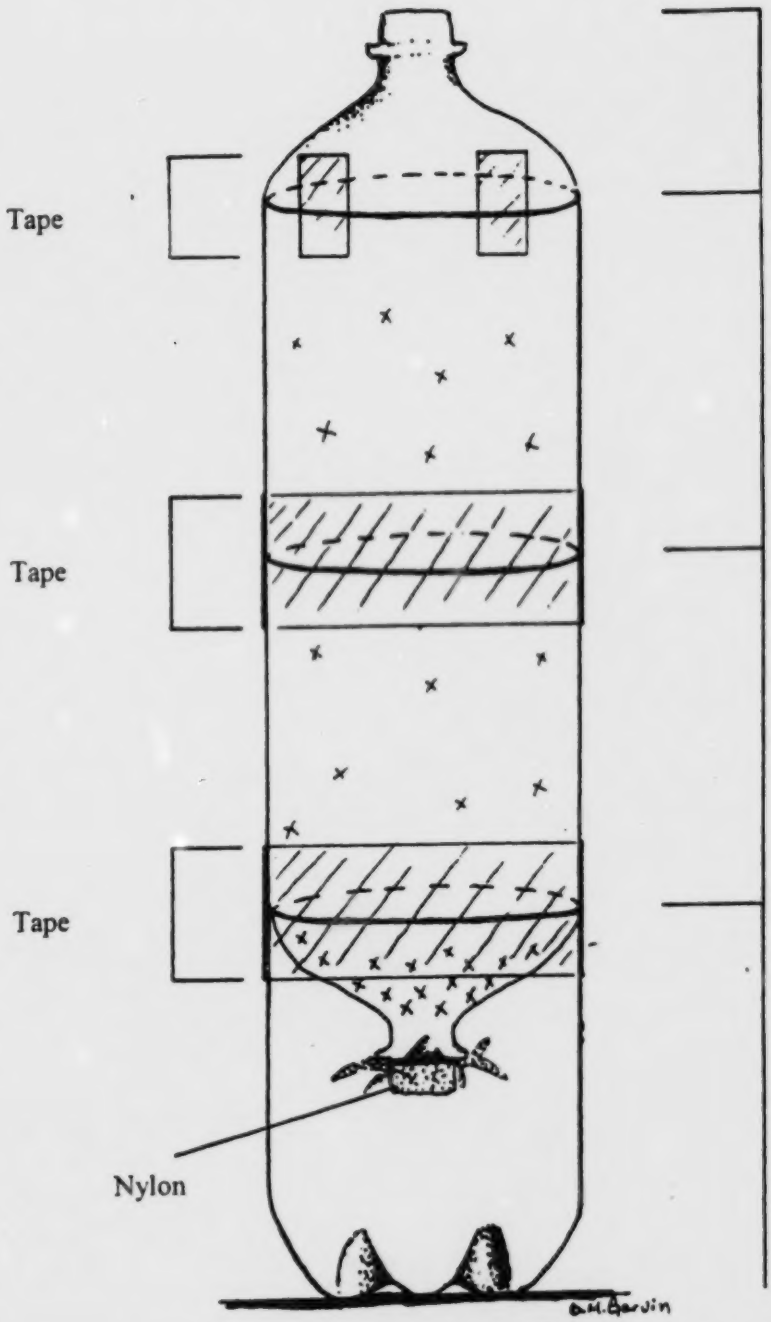
Data Sheet

Pop Bottle Composter



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Data Sheet

Soil Making/Composting

Name _____

Date	Describe the look, smell, feel, and appearance of your compost.

Inventory Of Worm Castings

This Too Shall Pass

GRADE LEVEL/TOPIC: 4-6/Soil

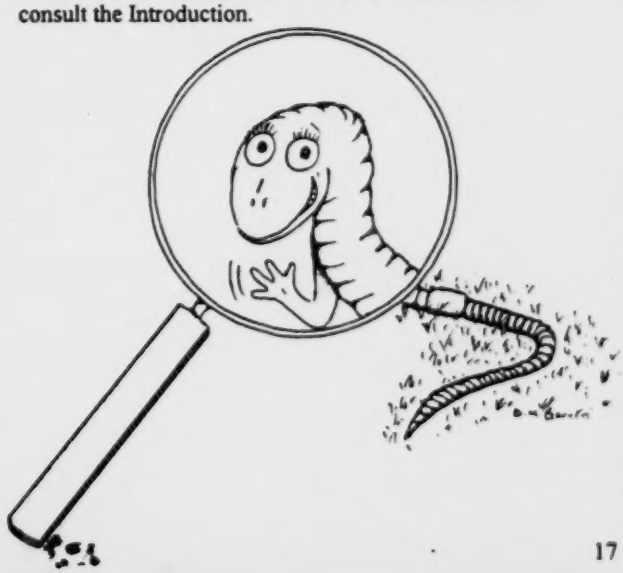
TIME REQUIRED/RECOMMENDED SEASON: 60-90 minutes initially, then 90 to 120 minutes one week later/ Spring or Autumn

SCIENCE SKILLS: Tool Making, Observing, Sampling, Mapping, Monitoring, Data Collecting and Recording

KEY WORDS: Soil, Mineral, Organic, Decomposition, Decomposers, Invertebrates, Earthworm, Castings, Sampling, Quadrat, Mapping

OVERVIEW

This Activity explores the rate of enriched soil production by earthworms in the Land Lab utilizing quadrats to sample the number and volume of earthworm castings produced and to map the area covered by the castings. It consists of the construction of a grid for use in the study (15-30 minutes), the preparation of quadrats and examination of worm castings in the Land Lab (45-60 minutes), the mapping and measuring of worm castings in the Land Lab and in the classroom (60-90 minutes) and the calculation of the rate of enriched soil production by earthworms for the Land Lab (15-30 minutes). This Activity may be divided into shorter sessions to accommodate your time allocation for science. If this is your first trip to the Land Lab, please consult the Introduction.



PURPOSE

1. Students will quantify the amount of enriched soil produced by earthworms in a sample plot over a one week period by (1) mapping worm castings from a grid and (2) counting and determining the volume of worm castings from the plot.

2. Students will estimate the total soil production by worms in the Land Lab from the amounts produced in their sample plots.

3. Students will be able to define and describe the role of earthworms in soil production.

MATERIALS

For The Class

- Inventory Of Worm Castings Data Sheet master
- Utility knife
- Coffee cans containing x and y coordinates on slips of paper (2)
- Sample of worm castings
- Graduated cc/ml container

For Each Group Of 2 Students

- Cardboard frame with 25 cm X 25 cm (10" X 10") internal dimension
- Cardboard squares removed from frames
- 46 cm (17") pipe cleaners (8) or equivalent lengths of yarn or string
- Glue or masking tape
- Scissors
- Popsicle sticks (4)
- Film canister
- Ruler
- Sheet of scrap paper
- Inventory Of Worm Castings Data Sheets (2)
- Clipboards with pencils (2)

Prepwork

Photocopy Inventory Of Worm Castings Data Sheets, one per student. Have students bring film canisters and large pieces of cardboard from home. To make cardboard frames, cut cardboard into pieces 30 centimeters (12 inches) square. Make a template 25 centimeters square (10 inches by 10 inches) and use it to remove a section of this size from the center of each cardboard piece with the utility knife. Retain the cardboard squares removed for measuring the sample plots. Make one frame for every two students. Cut sheets of paper into small slips and write the letters and numbers of the Land Lab's x and y coordinates on them. Place the x coordinates in one coffee can and the y coordinates in the other for the lottery. Collect a sample

of worm castings from your schoolyard to share with the students. Gather all other materials.

BACKGROUND INFORMATION

Soil, one of our most precious commodities, is composed of five basic components: rock particles, air, water, living organisms and organic materials. Rock particles are weathered from inorganic parent materials such as rocks and **minerals**, the elements and compounds which make up rocks. The remaining components find their way into the soil through the efforts of living organisms. **Organic** materials are produced by **decomposition**, the break down of dead plants and animals in the soil. Living organisms which aid in this process are called **decomposers**. The tunneling action of these organisms and the structure provided by the organic material which they produce create open spaces in the soil which can contain air and water.

The **earthworm** is one of the most common and easily recognized of the decomposers. It is classified as an animal without a backbone, or **invertebrate**, and a segmented worm, or annelid. The earthworm has a long, cylindrical body with 100-150 segments and a tube-like digestive tract running through its hollow body cavity with a mouth for feeding at one end and an anus for eliminating solid waste at the other. It also excretes liquid wastes through tube-shaped organs called nephridia, located one pair to each segment. The earthworm's stream-lined shape make it well adapted for movement through the soil. Longitudinal muscles (lengthwise) and circular muscles (around) contract alternately to propel the worm forward while two pairs of bristles, or setae, on the underside of each segment are extended and retracted to aid in this movement and to prevent the worm from being pulled easily from its burrow.

Adult worms also possess a thickened band, or clitellum, near the head end which produces mucus. This mucus serves to keep the body moist, lubricates the burrow, facilitates mating and provides a cocoon for the eggs. Its moisturizing role is especially important as earthworms breathe through moist skin. This fact explains why worms suffocate if left beneath a light or on a sidewalk to dry out and drown if they become trapped in soil saturated with water. It also explains why this normally nocturnal, light-sensitive animal makes appearances above ground in broad daylight during and after a rain. (Russell, 1990)

Earthworms literally eat their way through the soil, pulverizing compacted soil in their gizzards and digesting organic material out of it as it passes through their intestines. At night, the worms deposit this soil and food residue on the surface of the soil in pellets called **castings** and pull additional dead leaves and insects into the ground via their burrows. It is estimated that the approximately 50,000 worms per acre of fertile soil pass 9 to 16 metric tons (10 to 18 tons) of soil containing organic material through their digestive tracts each year, aerating and enriching the soil. (Holley, 1994)

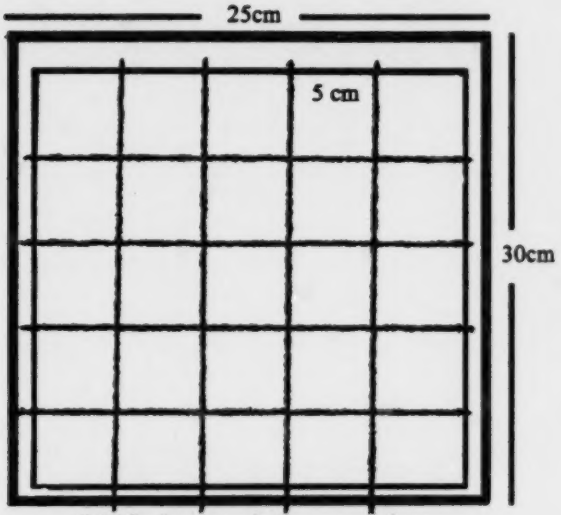
In this Activity, your students will utilize study plots called **quadrats** to sample the number and volume of castings being produced by earthworms and use their findings to estimate the rate of enriched soil production by the worms for the entire Land Lab. Quadrats are study plots standardized by size and shape and distributed in an appropriate, predetermined pattern throughout the area to be studied. (Roth, 1984) In this case, a lottery will be used to establish a random pattern for the quadrats. Using quadrats to take a **sample** is necessary in this study because the large area of the Land Lab would make it difficult to measure the total number and volume of castings being produced in it. Because these study plots are the same size and shape and will be studied in an identical way and because all coordinates within the Land Lab have an equal chance of being selected for the study, the quadrats are considered to accurately represent what is happening in the rest of the Land Lab.

Your students will quantify the production of castings in their quadrats in two ways: making a **map** of the castings and counting and measuring the volume of the castings. To map the castings, they will cover their quadrat with a hand-made grid which will divide the plot into even smaller, more manageable pieces and aid them in drawing the exact size, shape and location of each casting. The students will make their map on a Data Sheet within a similar grid. Their hand-made grid will also help them to make an accurate count of the castings. To measure their volume, the students will pulverize the castings and pour them into a graduated container.

BEFORE YOU GO

1. Review the background information on earthworms as decomposers and their role in soil formation with your students. Define worm castings and show the students a sample. Introduce censusing, sampling and mapping of these castings as ways to study the behavior of earthworms and their importance to the soil.

2. Give students an overview of the worm casting mapping and monitoring Activity, explaining that their study will take place over a one-week period. Describe the study, including the selection of sites, the removal of vegetation



Grid for inventorying worm castings

and previously formed castings from the area of one grid (625 square centimeters) and the measurements that the students will make at the end of the week.

3. Divide the students into teams of two. Describe a grid and its use, and have each team make one for use in their study.

a. Distribute the cardboard frames and pipe cleaners to the teams, and have the students get out glue, scissors, rulers and pencils.

b. Have each team use a ruler to mark off each internal side of their cardboard frame into five equal sections of 5 centimeters (2 inches) each.

c. Have the students glue their pipecleaners across their marks to form a grid of twenty-five equal squares.

d. Leave the grid to dry overnight.

4. Distribute popsicle sticks and cardboard squares to the students, and have them collect their pencils and rulers. Take them outside to the Land Lab.

PROCEDURE

1. Have each team select a quadrat site at random by drawing an x and a y coordinate from the two coffee cans and locating their site on the x-y axis. **If the location of the quadrat will damage or disturb another project, have the team return the paper slips they drew to the coffee cans and draw again.** Have each team write their x-y coordinates on their cardboard square for future reference and return the slips to the proper coffee cans before the next drawing.

2. To prepare the study site, have each team set the cardboard square on the ground and use the popsicle sticks to stake the four corners. This will mark a plot 25 centimeters by 25 centimeters (10 inches by 10 inches). Then have them move the cardboard square from the plot and pull all the vegetation inside the popsicle sticks. Have them use their rulers or a stick to scrape the worm castings from their plot and smooth out and pack the exposed soil. They should cover the quadrat with dried grasses or leaf litter to help retain moisture.

3. Leaving the popsicle sticks in place, take the students on a guided walk around the school grounds, observing examples of worm castings in those areas where the soil is bare. Return to the classroom.

4. One week later, return to the Land Lab to make measurements. Have each team bring their grid, Data Sheets, clipboards with pencils, a film canister and a ruler with them. Make sure that the students have filled in all preliminary information, including their names, the date and the x-y coordinates of their quadrat, on the Data Sheet.

5. Have each team locate their quadrat and set their grid over the plot. Assign one team member to count aloud the number of worm castings using the sections of the grid as a guide while the second member tallies them on the Data Sheet. Encourage the students to switch roles to double check their work.

6. Have both team members record the location of the castings within the grids on their Data Sheets. Encourage them to check their work for accuracy. When the map is complete, have the students collect the castings and deposit them into the film canister. They should cover the quadrat with dried grasses or leaf litter to protect the exposed soil.

7. After the entire class has completed the Activity, have the students use pacing as outlined in the Introduction to determine the length and width of the Land Lab in meters. Have them calculate the area of the Land Lab in square meters and record it on their Data Sheets. Return to the classroom.

8. To determine the volume of the worm castings, have each team empty the contents of their film canister onto a sheet of scrap paper and crush the castings. Call each team to your desk one at a time to measure the volume of the crushed castings in the graduated container. Have the students record the volume of the castings on their Data Sheets and return the castings to the canister for return to the Land Lab. Have them divide the volume of castings by

the area of their grid in square meters (625 square centimeters = 0.0625 square meters) to determine the rate of enriched soil production per week for their quadrat. Have the students record this rate on their Data Sheets.

CONCLUSION

1. Based on your findings, how much soil is produced by worms in your Land Lab in one week? On the board, list the total volume of castings produced from each team and add them to determine the total volume for all the quadrats. Multiply the area of one quadrat in square meters (625 square cm = 0.0625 square m) by the total number of quadrats to determine the area of the combined study plots in square meters.

2. Have the students divide the total volume of castings by the total area of the quadrats in square meters to get an average rate of enriched soil production for the study areas. Have them multiply this rate by the area of the Land Lab in square meters to estimate the volume of enriched soil produced by worms in the Land Lab. Have them record both values on their Data Sheets.

3. Based on their findings, have the students summarize the importance of earthworms in soil production.

JOURNAL QUESTIONS

Include the map of castings and the total number and volume of castings produced and the rate of soil production for the week in your journal.
Describe how earthworms contribute to the soil and the importance of their activities to plants and other animals.

EXTENSIONS

1. **Varying Rates**. Have the students compare production rates from different areas of the Land Lab. Making a map of the Land Lab showing all of the study sites labeled with the rates of enriched soil production will facilitate this.

2. **How Enriched Is Enriched?** Have your students save the worm castings that they have collected and combine them in a cup or planting pot. Have them plant beans in the container and compare the resulting plants with beans planted in a container of regular soil.

3. **Emerge And Be Counted!** Earthworms emerge from their burrows at night to deposit castings near their holes. Have your students consider how they might use castings to estimate the number of earthworms in an area of the Land Lab. If time permits, let them try their ideas.

4. **Worm Composting**. As a special project, set up a small worm composting bin in your classroom to compost your students' lunch waste. Encourage the students to keep records on the amount of garbage added and the amount of compost produced. NOTE: This project requires mail-ordering redworms (*Eisenia fetida*) from a commercial earthworm grower.

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Examines the earthworm and its environment, suggesting experiments to introduce basic ecological concepts as demonstrated by the earthworm's survival in its habitat.

Data Sheet

Inventory of Worm Castings

Name _____

Date _____ Week _____ Coordinates _____

Number of Castings		Area of Lab (m2)	
Volume of Castings (ml)		Rate of Soil Production (ml/m2/week)	
Average Rate of Soil Production (ml/m2/week)		Total Volume of Castings in Land Lab (ml)	

Use the other side of this sheet for your calculations.

Water In The Atmosphere

Up In Vapor

GRADE LEVEL/TOPIC: 4-6/Water

TIME REQUIRED/RECOMMENDED SEASON: 60 to 90 minutes for instrument construction, 90 to 120 minutes on subsequent days for monitoring and conclusion/ Spring or Autumn.

SCIENCE SKILLS: Tool Making, Observing, Measuring, Monitoring, Data Collecting and Recording, Predicting, Hypothesis Testing

KEY WORDS: Hygrometer, Barometer, Dew Point, Relative Humidity, Air Pressure, Dew, Condensation

OVERVIEW

This Activity examines the difference between atmospheric conditions (air temperature, air pressure, relative humidity and dew point) above a mowed lawn and those above the Land Lab using weather instruments constructed by the students. It consists of an introduction to atmospheric conditions and weather instruments and the construction of weather instruments (60-90 minutes), the measuring of atmospheric conditions above the mowed lawn and the Land Lab (60-90 minutes) on a subsequent day and the compilation of the data and hypothesis testing (30-45 minutes). This Activity may be divided into shorter sessions to accommodate your time allocation for science. If this is your first trip to the Land Lab, please consult the Introduction.

PURPOSE

1. Students will demonstrate atmospheric differences with respect to the water cycle between a natural area such as the Land Lab and a mowed lawn by (1) building and monitoring meteorological instruments and (2) recording and interpreting collected data.

2. Students will define and determine values of relative humidity, dew point and barometric pressure using their instruments.

MATERIALS

For The Class

- Masters for Balloon Barometer, Milk Carton Hygrometer, Dew Point and Water In The Atmosphere Information Sheets
- Water In The Atmosphere Data Sheet master
- Example of each weather instrument to be constructed
- Utility knife
- 2-liter pop bottle with label removed
- Aluminum pie tin
- Water
- 4"X 6" index card
- Scissors
- Clear tape
- Pen or pencil
- Cooler for ice
- Large sheet of newsprint
- Permanent marker

For Each Group Of 3-4 Students

- Copy of each Information Sheet
- Materials for balloon barometer, milk carton hygrometer and dew point experiment (See Information Sheets.)
- 30 cm X 46 cm (12" X 18") piece of heavy corrugated cardboard
- Glue
- Clipboard with pencil
- Water In The Atmosphere Data Sheet

Prepwork

Have the students bring from home those reusable materials which you do not have available in quantity: heavy corrugated cardboard, 2-liter pop bottles, narrow-mouthed glass juice jars, metal soup cans, half gallon milk cartons, old cotton shoe laces, balloon or rubber scraps, etc. Gather the remaining materials. Build a sample of each of the weather instruments to be constructed by your students. With the utility knife, cut the heavy corrugated cardboard

into 30 cm X 46 cm (12" X 18") pieces until there are enough for one per group of three to four students. Photocopy the Information Sheets and the Water In The Atmosphere Data Sheet, producing enough copies for one per group of students.

BACKGROUND INFORMATION

For an introduction to weather and the water cycle, see the Weather Station Activity for grades 2-3. This Activity involves more sophisticated weather monitoring and will attempt to find differences between certain atmospheric conditions, namely temperature, air pressure, relative humidity and dew point, in a natural area such as the Land Lab and the same conditions over a mowed lawn.

The earth's atmosphere is composed of air, a mixture of gases which, within 45 miles of the earth's surface, includes inert nitrogen (78%), oxygen (21%) and smaller quantities of carbon dioxide, argon, neon, radon, helium, krypton, xenon, hydrogen, methane, nitrous oxide, and ozone (Lehr, Burnett and Zim, 1975). These gases have mass and exert more than 14 pounds per square inch (.98 kilograms per square centimeter) of pressure on the earth's surface. **Air pressure**, or barometric pressure, is used by meteorologists to plot lines of equal pressure, or isobars, over the earth's surface and to determine the positions and movements of weather fronts.

Air pressure is measured using a **barometer**. The two types of barometers are the mercurial barometer and the aneroid barometer. The mercurial barometer measures air pressure by balancing a column of mercury with a column of air while the aneroid barometer records the changes in a metal container from which all the air has been removed as a result of changes in air pressure. The bottle barometer which you will demonstrate in class works similarly to a mercurial barometer while the balloon barometer that your students will construct works in much the same way as an aneroid barometer. Mercurial barometers are considered to be more accurate. A drop in pressure generally means that warmer, wetter weather is forthcoming. Low air pressure generally indicates a higher concentration of water vapor in the air. As a diagram of the water cycle illustrates, water vapor is lighter than other gases in the air.

Air can contain up to 4% water vapor (Lehr, Burnett and Zim, 1975). Water vapor in the air is called humidity. **Relative humidity** is the amount of water vapor in the air expressed as a percentage of the maximum amount of vapor that the air could hold at its current temperature. Warm air can hold more vapor than cold air, so, given a constant amount of water vapor in the air, the relative humidity increases as the air cools and decreases as the temperature rises.

Relative humidity is measured using a psychrometer, or **hygrometer**, which includes two thermometers: a dry bulb and a wet bulb. The dry bulb thermometer measures the air temperature. The wet bulb thermometer is surrounded by a wet cloth from which water continues to evaporate until the surrounding air cannot hold any more water vapor. Because the process of evaporation causes cooling, the wet bulb temperature will be equal to or lower than the dry bulb temperature and dry air will cause a greater difference between the dry bulb and wet bulb readings. This difference can be used to determine the relative humidity by reading a chart. (See Milk Carton Hygrometer Information Sheet.)

Another condition which reflects the state of water in the atmosphere is the **dew point**. The dew point is the temperature at which air can no longer hold its current load of water vapor; at the dew point, the relative humidity of the air is 100%. The dew point can be determined by lowering the temperature of a can of water until water vapor from the surrounding air begins to condense on it. **Condensation**, or the change of water vapor into liquid droplets called **dew**, is the way in which the air reduces its load of vapor. The temperature of the water when this occurs is the dew point. If the dew point is close to the actual air temperature, the probability of fog, rain or snow is much higher.

Natural areas such as the Land Lab can have a significant impact on the water in the atmosphere. They reduce the amount of standing water by increasing the rate of its absorption by vegetation and soil. They also moderate temperatures by increasing the amounts of shade and transpiration. These effects on temperature and water should be reflected in the atmospheric conditions above the Land Lab as they are compared to those conditions above a mowed lawn. How big a difference they make is left for your students to determine! However, a lower temperature, higher relative humidity and a higher dew point would be expected. It is unlikely that your students will observe any significant difference in air pressure between two points so close together. However, if the difference in temperature is significant, the balloon barometers may indicate higher pressure over the Land Lab due to the cooling of the air in the bottle.

BEFORE YOU GO

1. With your students, review the water cycle to reinforce that there is constantly water in the atmosphere. Define weather, emphasizing the role of the water cycle.

2. Briefly discuss the weight of the atmosphere and the pressure which it exerts on us. Demonstrate air pressure with a bottle barometer.
(a) Fill the aluminum pie pan about half full of water.
(b) Fill the 2-liter pop bottle about three-quarters full of water.
(c) Covering the mouth of the bottle with your thumb, turn the bottle into the aluminum pie pan. Quickly remove your thumb.
(d) Cut a 15-centimeter (6-inch) long strip from the index card and tape it to the side of the bottle. Mark the level of the water in the bottle on it in pen or pencil.
(e) Explain to the students that the water remains in the bottle because the pressure of the water and the air in the bottle is balanced by the pressure of the air on the water in the pan. The level of the water in the bottle will move up and down as the air pressure increases and decreases (Mandell, 1990).

3. Compare the bottle barometer with the balloon barometer which the students will construct. Define relative humidity and demonstrate the use of the sample hygrometer. Define and demonstrate dew point using a metal can of water and ice. Demonstrate the use of a thermometer to take the air temperature at 15 centimeters (6 inches) above the ground and at 1.2 meters (4 feet) above the ground. Explain that they will be taking the air temperature at different levels to see if the distance of the air from the vegetation has any effect on its temperature.

4. Divide the students into groups of three or four. Have the groups construct one of each instrument as outlined in the information sheets. When they have finished, have them glue their instruments in place on a piece of heavy corrugated cardboard. Allow the glue to dry overnight.

5. Encourage the groups to discuss where they would expect to find the highest and/or lowest readings for each of the atmospheric conditions: in the Land Lab or over the mowed lawn. Write their predictions on the board.

6. Distribute one clipboard with pencil and Data Sheet to each group.

PROCEDURE

1. Take students outside and have them set up their weather stations on mowed grass. Have them record the appropriate data and their readings on the Data Sheets.

2. Move to the Land Lab. Have each group choose a relatively flat surface on which to set the instruments. Have the students fill in the Data Sheets as before. Return to the classroom.

CONCLUSION

1. Compile the data onto the board or a sheet of newsprint. Emphasize that temperatures are sometimes more extreme during the spring, summer and autumn months on mowed grass because of lack of vegetation.

2. Discuss why groups may have received different readings. What weather variables and/or vegetation situations could affect the readings? (These could include direct sunlight, air temperature, quantity/height of vegetation, amounts of transpiration and shade, etc.) Did the students' hypotheses turn out to be correct?

JOURNAL QUESTIONS

Based on what you observed, what is one problem with the currently rapid rate of deforestation all over the world? What will be the long-term effects weather-wise of uncontrolled deforestation and development? What solutions can you suggest to the problem.

EXTENSIONS

1. **Air on the Move**. Have the students try to measure the air flow at ground level in the Land Lab and on a mowed lawn. Have them use a cup anemometer or an instrument of their own design. Are they able to detect any difference in air flow between the two areas? How would they explain any difference?

2. **How Hot Do You Feel?** Just as wind can make temperatures feel cooler on a cold day (wind chill factor), humidity can make temperatures feel warmer on a hot day. Have the students use their readings of the air temperature and relative humidity and the Heat Index chart on the Water In The Atmosphere to determine how hot it feels. Do they agree with their findings?

3. **Monitoring.** Have the students take measurements over the course of a week each month year-round to note changes and differences among the seasons.

4. **Play Meteorologist.** Encourage the students to use their weather stations to take measurements over a series of days and to try and predict the weather. Have them prepare a weather report based on their predictions.

5. **Dear Senator.** Have your students write a letter to their Representative or Senator, describing the experiment and giving their opinions on deforestation.

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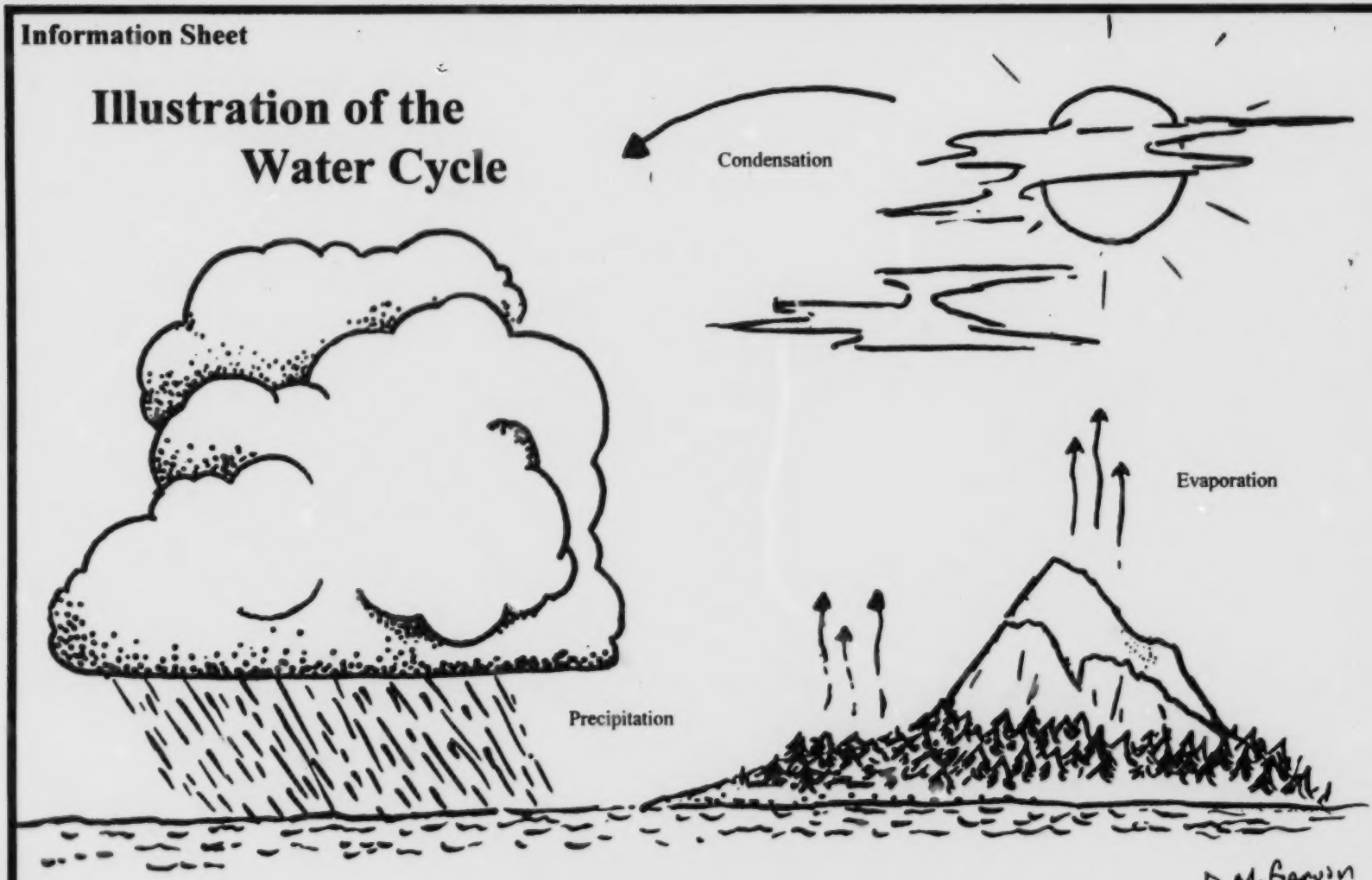
Experiments, tricks and things to make are used to explore water in all its forms.

Information Sheet

Illustration of the Water Cycle



Instruction Sheet

BALLOON BAROMETER INSTRUCTION SHEET

What You Need

- Narrow-mouthed glass juice jar, at least 6" tall and 3" in diameter
- Balloon or other thin rubber scrap
- Rubber band or piece of string
- Drinking straws (2)
- Straight pin
- Small paper cup
- 2.5 cm X 7.6 cm (1" X 3") strip of a 3" X 5" index card
- Pen or pencil
- Clear tape
- Scissors
- Glue

Making Your Barometer

1. Stretch the balloon or rubber scrap taut over the mouth of the jar and fasten it with the rubber band or string.

2. Cut a 10-centimeter (4-inch) section of the drinking straw, and attach the straight pin to one end with clear tape. Glue the other end to the rubber lid, starting at the center of the balloon so that the pin end extends out beyond the edge as shown.

3. Poke a hole in the bottom center of the paper cup with a pencil or scissors and insert a drinking straw into the hole.

4. Mark the 7.6-centimeter (3-inch) long strip of the index card with a series of horizontal lines. Attach it with clear tape to the straw in the cup at the level of the straight pin so that you can follow the movements of the pin.

5. Attach the jar and the paper cup to a portable surface (ex. heavy corrugated cardboard or box lid).

Using Your Barometer

1. Set the barometer on a level surface, and observe the movement of the unattached end of the straw with the straight pin.

2. **When your pointer moves down**, the air pressure inside the jar is greater than the air pressure outside. Record this on your Data Sheet as low pressure or as an arrow indicating that the **air pressure is decreasing (↓). This could mean that a storm is approaching.**

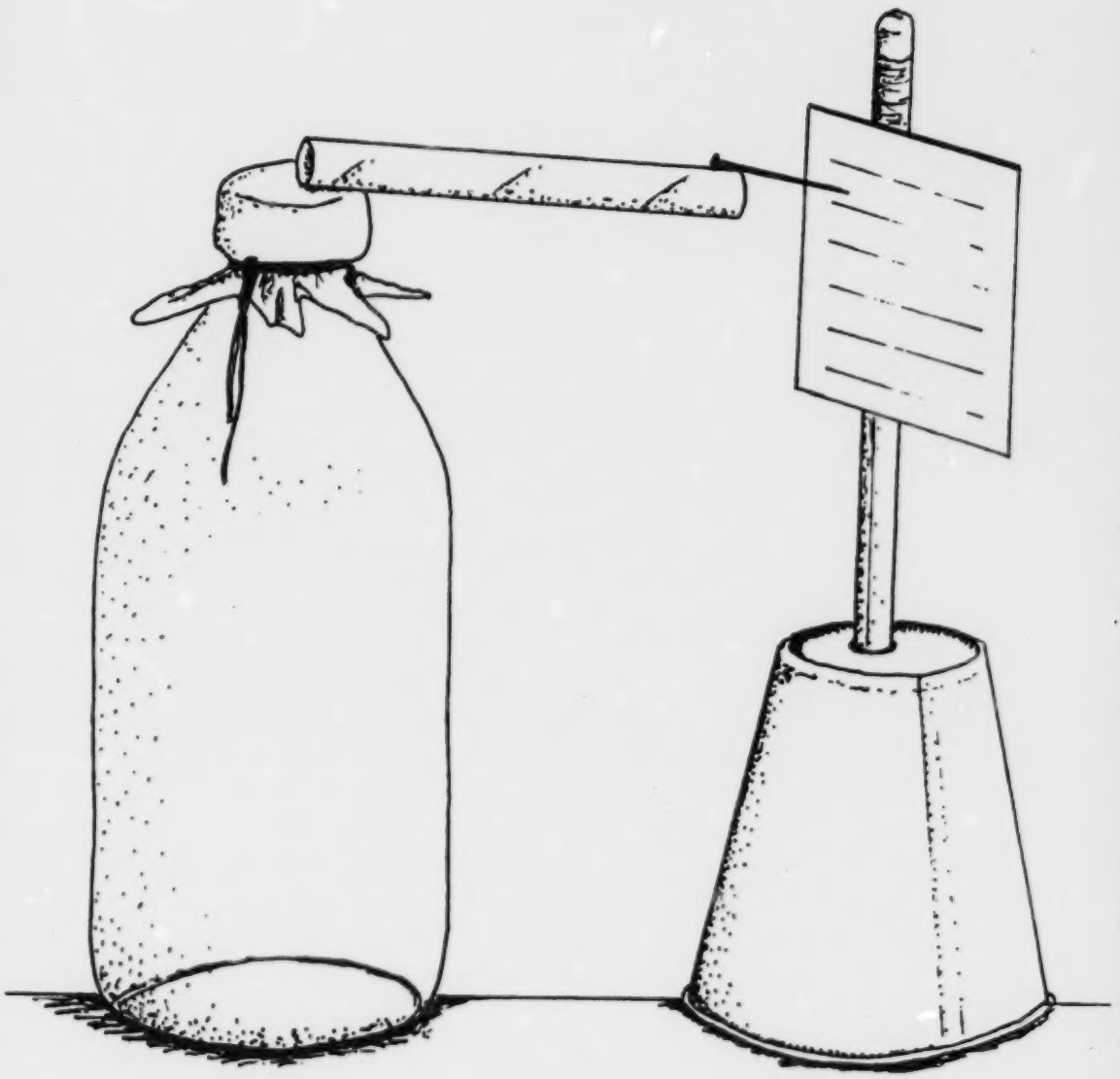
3. **When your pointer moves up**, the air pressure is greater outside than the air pressure inside the jar. Record this on your Data Sheet as high pressure or as an arrow indicating that the **air pressure is increasing (↑). This is usually a sign that the weather is changing for the better.**

4. Raising or lowering the air temperature in the jar may also cause the rubber lid to bulge out or in, giving a false reading of the air pressure.

Source: Mandell, 1990

Information Sheet

Balloon Barometer



35

Instruction Sheet

MILK CARTON HYGROMETER INSTRUCTION SHEET

What You Need

- Linear thermometers with bulbs (2)
- Old cotton shoelace or other small piece of cotton material
- Piece of thread or string
- Half gallon milk carton
- Thick rubber bands (2)
- Scissor

Making Your Hygrometer

1. Check the two thermometers to make sure that their temperature readings are the same.

2. Cut the tip off the old shoelace and slip the cotton tube formed by the lace over the bulb of one of the thermometers. Secure the shoelace or other piece of cotton material wrapped around the bulb above and below it with thread or string. Leave a piece of the shoelace or other material dangling below the thermometer like a wick as shown. This will serve as the wet bulb thermometer.

3. Attach the thermometers to two sides of the milk carton using the rubber bands.

4. Cut a small hole in the milk carton just below the wet bulb thermometer, and push the wick through the hole.

5. Attach the milk carton to a portable surface (ex. heavy corrugated cardboard or box lid).

6. When you are ready to use your hygrometer, add water to the milk carton to the level of the hole so that the wick will remain wet.

Using Your Hygrometer

1. Set the hygrometer on a level surface, and wait 5 to 10 minutes for the wet bulb thermometer to reach a constant temperature.

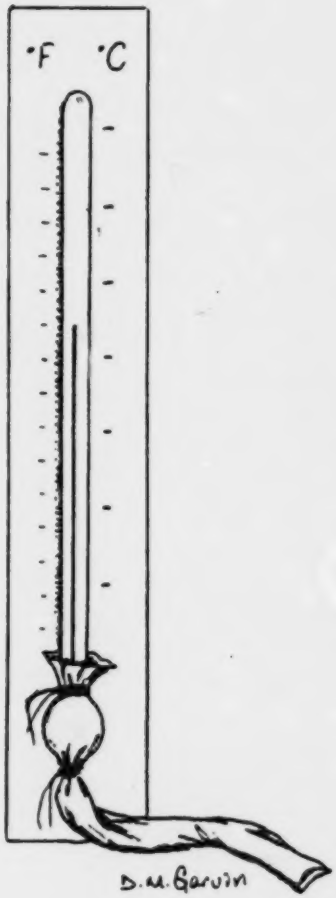
2. Read the dry bulb and wet bulb thermometers. Record these temperatures on your Data Sheet in °F. Calculate the difference between the dry bulb and wet bulb temperatures, and record this value on your Data Sheet in °F. The lower the humidity, the greater the difference between the temperatures will be. If the temperatures are the same, the relative humidity is 100%.

3. Using the dry bulb temperature (the air temperature) and the difference between the two temperatures, read the relative humidity from the Relative Humidity Table on the Water In The Atmosphere Information Sheet. Record the relative humidity on your Data Sheet as a percentage.

Source: Mandell, 1990

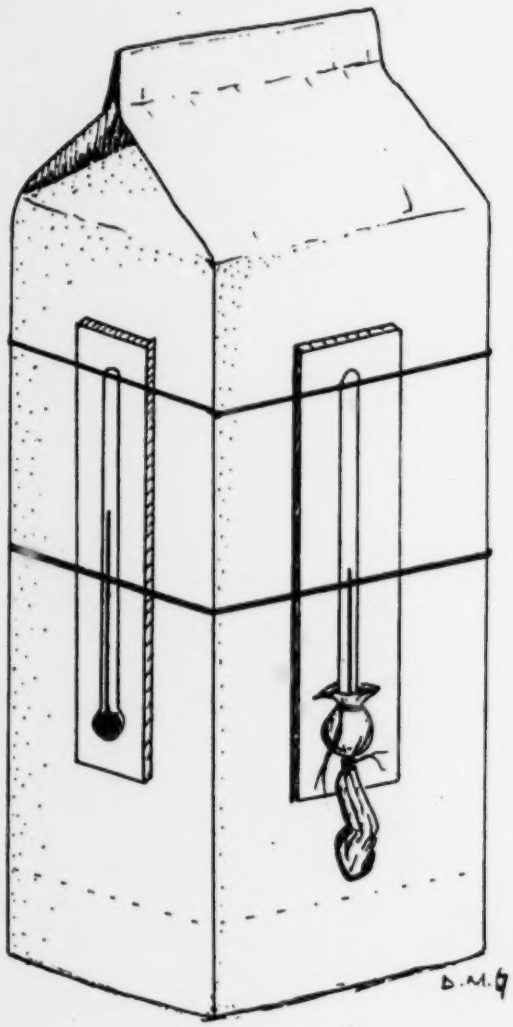
Information Sheet

Milk Carton Hygrometer



Wet Bulb Thermometer

Milk Carton Hygrometer



Water Level

37

DEW POINT INSTRUCTION SHEET

What You Need

- Metal soup can
- Water
- Thermometer
- Ice cubes

Preparing Your Dew Point Experiment

1. Attach the metal soup can to a portable surface (ex. heavy corrugated cardboard and box lid).

2. When you are ready to do the dew point experiment, fill the can with water.

Doing Your Dew Point Experiment

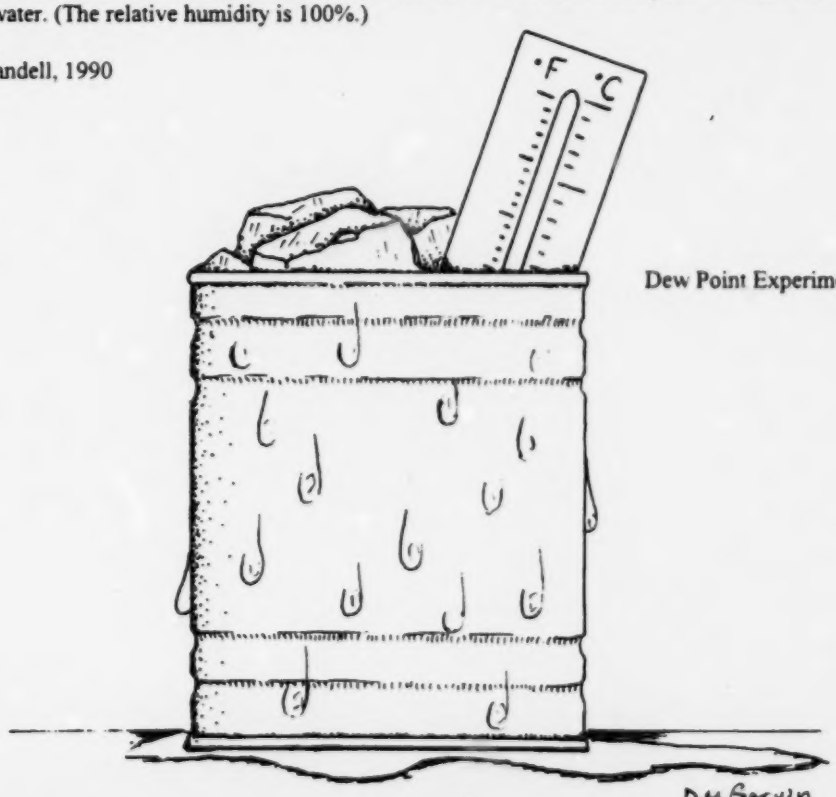
1. Set the metal can on a level surface. Using the thermometer, take the temperature of the air at 15 centimeters (6 inches) and 1.2 meters (4 feet) above the ground. Record these air temperatures on your Data Sheet in °F.

2. Make sure that the outside of the can is dry. Place the thermometer in the can.

3. Add ice to the can, a little at a time, and carefully stir the water with the thermometer. Continue this procedure, watching the thermometer closely, until water, or dew, condenses on the outside of the can.

4. Read from the thermometer the temperature at which this condensation occurs, and record it on your Data Sheet as the dew point in °F. The ice water in the can has cooled the air around it to the point at which the air can no longer hold its load of water. (The relative humidity is 100%.)

Source: Mandell, 1990



Dew Point Experiment

Data Sheet

Water In The Atmosphere

Names _____ _____

_____ _____

Date _____

Weather Conditions (Circle): Sunny Cloudy Windy

Rainy Other _____

Water Conditions (Circle): Dew on Ground Standing Water Present

Ground Frozen Other _____

	Mowed Lawn	Natural Area
Barometer Reading (low, ↓ , high, ↑)		
Hygrometer Wet Bulb Reading (°F)		
Hygrometer Dry Bulb Reading (°F)		
Dry Bulb - Wet Bulb Value (°F)		
Relative Humidity (%)		
Air Temperature at 6 inches Above Ground (°F)		
Air Temperature at 4 feet Above Ground (°F)		
Dew Point (°F)		

Information Sheet

Water In The Atmosphere

Relative Humidity Table

DIFFERENCE BETWEEN
DRY-BULB AND WET-BULB TEMPERATURES

DRY-BULB TEMPERATURE (°F)

	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24
10	78	56	34	13														
15	82	64	46	29	11													
20	85	70	55	40	26	12												
25	87	74	62	49	37	25	13	1										
30	89	78	67	56	46	36	26	16	6									
35	91	81	72	63	54	45	36	27	19	10	2							
40	92	83	75	68	60	52	45	37	29	22	15	7						
45	93	86	78	71	64	57	51	44	38	31	25	18	6					
50	93	87	80	74	67	61	55	49	43	38	32	27	16	5				
55	94	88	82	76	70	65	59	54	49	43	38	33	23	14	5			
60	94	89	83	78	73	68	63	58	53	48	43	39	30	21	13	5		
65	95	90	85	80	75	70	66	61	56	52	48	44	35	27	20	12	5	
70	95	90	86	81	77	72	68	64	59	55	51	48	40	33	25	19	12	6
75	96	91	86	82	78	74	70	66	62	58	54	51	44	37	30	24	18	12
80	96	91	87	83	79	75	72	68	64	61	57	54	47	41	35	29	23	18
90	96	92	89	85	81	78	74	71	68	65	61	58	52	47	41	36	31	26
100	96	93	89	86	83	80	77	73	70	68	65	62	56	51	46	41	37	33

Example: If the dry bulb temperature is 65 (see numbers at left), and the wet bulb temperature is 62, the difference is 3 degrees (see numbers at the top of the chart), and so the relative humidity is 85% (see the place where they intersect).

How Hot Do You Feel? (Extension #2)

Heat Index

RELATIVE HUMIDITY(%)

AIR TEMPERATURE (°F)

	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
140																
135																
130																
125																
120	139	148														
115	127	135	143	151												
110	117	123	130	137	143	150										
105	109	113	118	123	129	135	142	149								
100	101	104	107	110	115	120	126	132	138	144						
95	94	96	98	101	104	107	110	114	119	124	130	136				
90	88	90	91	93	95	96	98	100	102	106	109	113	117	122		
85	83	84	85	86	87	88	89	90	91	93	95	97	99	102	105	108
80	77	78	79	79	80	81	81	82	83	85	86	86	87	88	89	91
75	72	73	73	74	74	75	75	76	76	77	77	78	78	79	79	80
70	66	67	67	68	68	69	69	70	70	70	70	71	71	71	71	72

Source: Mandell, 1990

Pollination

Sex and the Single Flower

GRADE LEVEL/TOPIC: 4-6/Plants

TIME REQUIRED/RECOMMENDED SEASON: 105 minutes with at least 3 hours in between activities/ A warm day in Spring or Fall

SCIENCE SKILLS: Observing, Predicting, Data Collecting and Recording, Model Building

KEY WORDS: Angiosperm, Flower, Sepal, Petal, Anther, Filament, Stamen, Pollen, Pistil, Egg, Ovule, Stigma, Ovary, Style, Nectar, Pollinate, Cross Pollinate, Seed, Fruit

OVERVIEW

In this Activity, your students will be introduced to the parts of a flower and the concept of pollination (15 minutes). They will each build a model of a flower, including a reservoir for nectar (30 minutes). The students will place the models in the Land Lab and observe real flowers (30 minutes). Several hours later, your class will return to the models and collect data for two five-minute periods (30 minutes). Feel free to break this Activity into smaller lessons. If this is your first trip to the Land Lab, please consult the Introduction.

PURPOSE

1. Students will demonstrate the features of flowers which attract insects by constructing working models.

2. Students will describe the mechanics of pollination, form and function (fruit and seed formation and propagation).

MATERIALS

For Class

- Perfect Flower Information Sheet Master
- Illustrations of various flower types and forms from school library or from *Newcomb's Wild-Flower Guide*
  Optional: cut flowers from a garden or store (not from the Land Lab!)
- Pitcher and spoon or empty 2-liter soda bottle (for mixing sugar water)
- Sugar water ("nectar") made from 1/2 cup sugar or honey and two cups water, or a 1:4 sugar to water ratio

For Each Group Of Twelve Students

- Styrofoam egg carton

For Each Student

- Perfect Flower Information Sheet
- Scissors
- Template of flower petals on white or colored construction paper
- Glue sticks
- Crayons
- Thumbtacks (2)
- Clipboard and pencil
- Data sheet

Prepwork

Before this Activity, prepare sugar water in pitcher or 2-liter bottle. Cut egg cartons such that each student has a one cup section. Photocopy enough copies of the "perfect flower" illustration and the flower template such that each student has one. Decide where in the Land Lab you want the students to install their flower models. The location should be small enough to ensure easy observation by each student of his or her model.

BACKGROUND INFORMATION

The flower is the most admired part of any **angiosperm**, or flowering plant. Scientists can tell from the fossil record that angiosperms are a relatively recent arrival on earth. Interestingly, the rise in numbers and kinds of angiosperms coincides with the rise of insect species. A **flower** is a group of modified leaves with specialized parts. The shape, color, smell and markings of a flower are all designed to promote pollination (also known as fertilization). This process is achieved when pollen is carried by insects, mammals, birds or even wind or water to a flower's reproductive parts (Stokes, 1984). The results of pollination are seeds.

Flowers have four primary parts: sepals, petals, pistil and stamens. The **sepals** are leafy parts which encase the developing flower, or flower bud. The **petals** are an inner lining of modified leaves which attract and guide animals such as insects, birds or mammals to the inner parts of the flower. Plants' flowers employ the fragrance of nectar and/or their petals. They offer pollinators directional guidelines and runways on the petals, from the visible and ultraviolet spectrum. Some flowers have even developed a target or "bulls-eye" construction of their petals related to the sex parts to facilitate effective pollination.

The flower's inner parts are all reproductive organs. The **pistil** is the female part and includes the **eggs (ovules)** which are contained within the **ovary**. The tall, hollow structure extending vertically from the ovary is the **style**. The opening at the top of the style is called the **stigma**. The male parts, or **stamens** include long hair-like stalks called **filaments**. At the tips of the filaments are **anthers** where the male sex cells, or **pollen**, are produced (Stokes, 1984).

When pollen is placed on the stigma by insects, birds, mammals or the wind, the pollen develops a tube which grows down the style to the eggs. At this point the plant has been **pollinated.** The eggs and the surrounding ovary begin to enlarge as the egg develops into a **seed**. The ovary develops into the seed's surrounding fruit. The mature ovary, or **fruit**, can be soft and fleshy like a berry or it may be dry and thin like the helicopter of a maple tree. As the fruit continues to grow and develop, the former flower's petals, sepals, filaments and anthers drop off. They have served their purpose and are no longer needed (Stokes, 1984).

When pollen from a plant lands on the stigma of the same plant and a seed can be formed, the plant is referred to as self-pollinating. Because both the egg and pollen are from the same plant, the resulting seed will be almost exactly like its parent (Stokes, 1984).

When the pollen from a plant lands on the stigma of another plant, it is called **cross-pollination**. The seed which develops from these two plants will be different from either of the parent plants. These differences are very important to the young plant which will grow from the cross-pollinated seed. This process allows the new plant to be more resistant to disease or more adapted to the soil or water within its local environment (Stokes, 1984).

There are many ways plants facilitate cross-pollination. Some plants such as oak trees produce huge amounts of pollen so that there is a better chance that it will be carried to other oak trees. Most plants are pollinated by insects which come to flowers for their nectar. **Nectar** is a sugary juice which attracts many pollinators including insects, hummingbirds and bats. Some of these animals eat the nectar; many eat the pollen they find at the flower. Bees eat nectar and collect pollen as food for their larva. The pollen often gets stuck to other parts of the animals' bodies, and is carried to the flowers of other plants while the bees continue their search for food.

Pollination can only occur between flowers of plants of the same species, for example, Trout Lily to Trout Lily. Pollinating animals usually feed on one plant species' flowers at a time. This is called flower constancy and is the primary reason pollen gets from one Trout Lily to another (Stokes, 1984).

This rather lengthy treatment of the phenomena of pollination underscores its importance in our everyday lives. Many species of plants simply can not produce fruit without first being pollinated by a very specific kind of insect. This Activity will explore the factors that attract insects to the flowers that are now or soon will be in your Land Lab by feeding them artificial nectar.

BEFORE YOU GO

1. Ask your students to name some examples of flowers. Explain that flowers, because of the way they look, attract insects and other animals. These animals transfer pollen from flower to flower while feeding, thus pollinating the plants.

2. Hand out the Perfect Flower Information Sheets and other flowers or flower pictures you have gathered. Define flower parts and show the location of nectar and pollen. Discuss features of flowers such as color, scent, stripes and shape that attract pollinators.

3. Discuss what a model is and construct flower models with your class to explore the features which pollinating insects find attractive. These flower models will be placed in your Land Lab and monitored by your class. See illustration.

Flower Models:

a. Distribute crayons, scissors and a gluestick to each student. Distribute a styrofoam egg carton 'cup' and a copy of the flower template on white or colored paper to each student.

b. Instruct students to color and cut out the flower petals of their template. Have them glue the egg carton cup to the flower to complete the model. The point is to make a model that will attract insects, so encourage originality, creativity and noncon formity. Leave to dry overnight.

PROCEDURE

1. Take artificial nectar, the box of thumbtacks and the students' models and go to the Land Lab. Try to do this part of the Activity early in the morning, as that is when pollinators are most active.

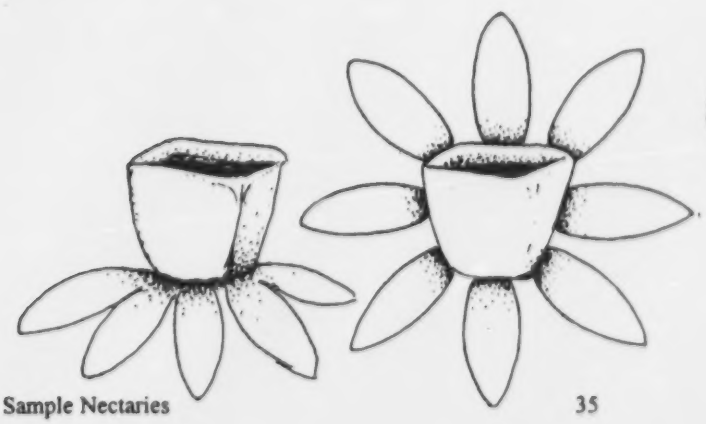
2. Give each student a thumbtack and instruct them to place their model where they think it will be visited by the most insect pollinators. The top or sides of fenceposts, in tall grass or beneath trees are all options. Remember, the locations must be observable from a safe distance.

3. Carefully fill each flower model halfway with sugar water.

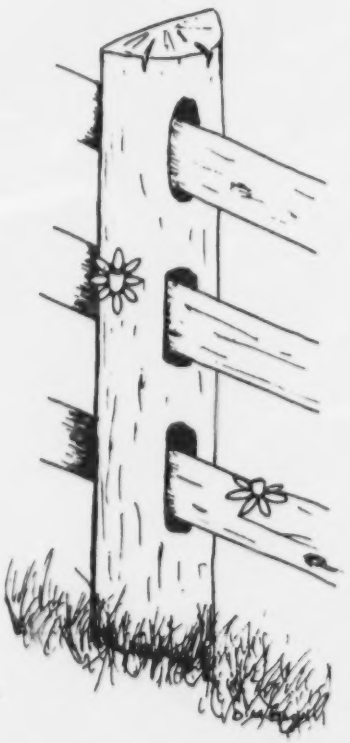
4. Once all the flowers are filled and placed, take a few minutes to observe the real flowers of the Land Lab. You may observe tree flowers or grass flowers, as well as the more showy insect-pollinated flowers. Point out that, while they may not look like much, plants like trees and grasses also have flowers and are pollinated. The fact that their flowers are dull signals that they are wind pollinated. Insect-pollinated flowers are usually brightly colored. Try also to observe any insect pollinators. Return to the classroom.

5. Go to the Land Lab at least once during the afternoon to monitor the flower models. Instruct your students to use the Data Sheet to record their observations. They should count the number of insects seen at their flowers in two five-minute periods, as timed by your watch.

6. Empty liquid from flower models and do #1 from the Conclusion or return to classroom.



Sample Nectaries

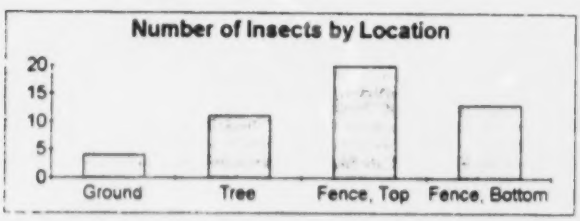


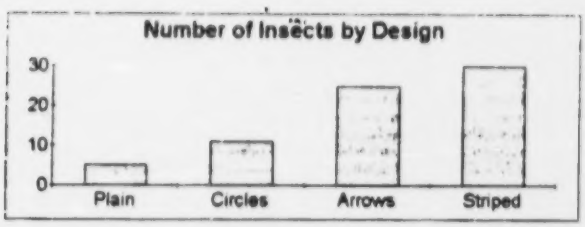
Placement of nectaries on Land Lab fence

CONCLUSION

1. Either in the Land Lab or back in the classroom, give students time to complete their drawings and to add up their data. Help students pool their data by writing location headings on the board such as, "fence, ground, under a tree," and having students write their total number of insects under the appropriate heading. This can also be done by grouping models by the designs that were used. Have students add up all of the insects seen in each category.

2. Discuss the results obtained by the students. Based on the number of insects seen and the placement of the models, what attracted the most potential pollinators? Make a graph of the results, plotting number of insects seen against either location or design (see example data, below).





3. Discuss how "There is no such thing as a free lunch." What do the bees get in return for carrying pollen from flower to flower? What does the plant get in return for producing the nectar? Can the students think of any other relationships in nature that are this way? (Sharks and remoras, alligators and the birds that clean their teeth and are unharmed are two examples.)

JOURNAL QUESTIONS

Draw and label the flower parts of a flower in the Land Lab.
Write a story about a flower that will do anything to get pollinated.
Given the results of the class draw a picture of the ultimate flower model and write a paragraph about how it works.

EXTENSIONS

1. **Parts Are Parts.** Have students bring in flowers from their own gardens and observe the flower parts.

2. **National Wildflower Research Center.** This is a national group dedicated to the research and enjoyment of wildflowers and founded by Ladybird Johnson.

National Wildflower Research Center
2600 FM 973 North
Austin, TX 78725-4201
(512) 929-3600

3. **Improving on Nature?** Have your students design their own flower petals, nectaries and 'nectar'.

4. **A Sticky Situation.** Create pollen traps of paper smeared with Vaseline. See Activity titled "Seed Dispersal" for more information.

5. **Pollen Exam.** Collect pollen with cotton swabs from live flowers. Discuss its appearance and consistency. Examine under a microscope.

6. **More With Models.** Add sex parts to flower models. Use confectionery sugar as pollen.

7. **It's Showtime.** Create a puppet from a dark sock to represent a pollinating visitor.

REFERENCES / ADDITIONAL READING

Raven, Peter H., Ray F. Evert and Susan E. Eichhorn. 1986. Biology of Plants. Worth Publishers, Inc. New York, NY. pp. 353-369.

Stokes, Donald and Lillian. 1985. A Guide to Enjoying Wildflowers. Little, Brown and Company, Limited. Boston, MA. pp. 8-14. (TLCPL)

Newcomb, Lawrence. 1977. Newcomb's Wildflower Guide. Little, Brown and Company. Boston, MA. 489 pp. (TLCPL)

CHILDREN'S SCIENCE/TRADE BOOKS

Dowden, Anne O. 1990. The Clover and the Bee: A Book of Pollination. Thomas Crowell. New York, NY. (TLCPL)
Explains the process of pollination, describing the reproductive parts of a flower and the role that insects, birds, mammals, wind and water play in the process.

Rahn, Joan E. Ginny L. Winter, Illustrator. 1980. How Plants Are Pollinated. Antheneum. New York, NY. (TLCPL)
Describes the many ways that flowers are pollinated and the pollinating agents that make differences in flowers possible.

Data Sheet

Pollination

Name _____

Date _____

1. Draw your flower model below.

2. When your teacher says, "Go," make a tally mark for each insect you see at your flower model. Write the Total in the appropriate box.

Tally of Insects	Total Insect	Class Totals

3. Based on the results of your class, what flower design and location are the most favorable to pollinating insects?

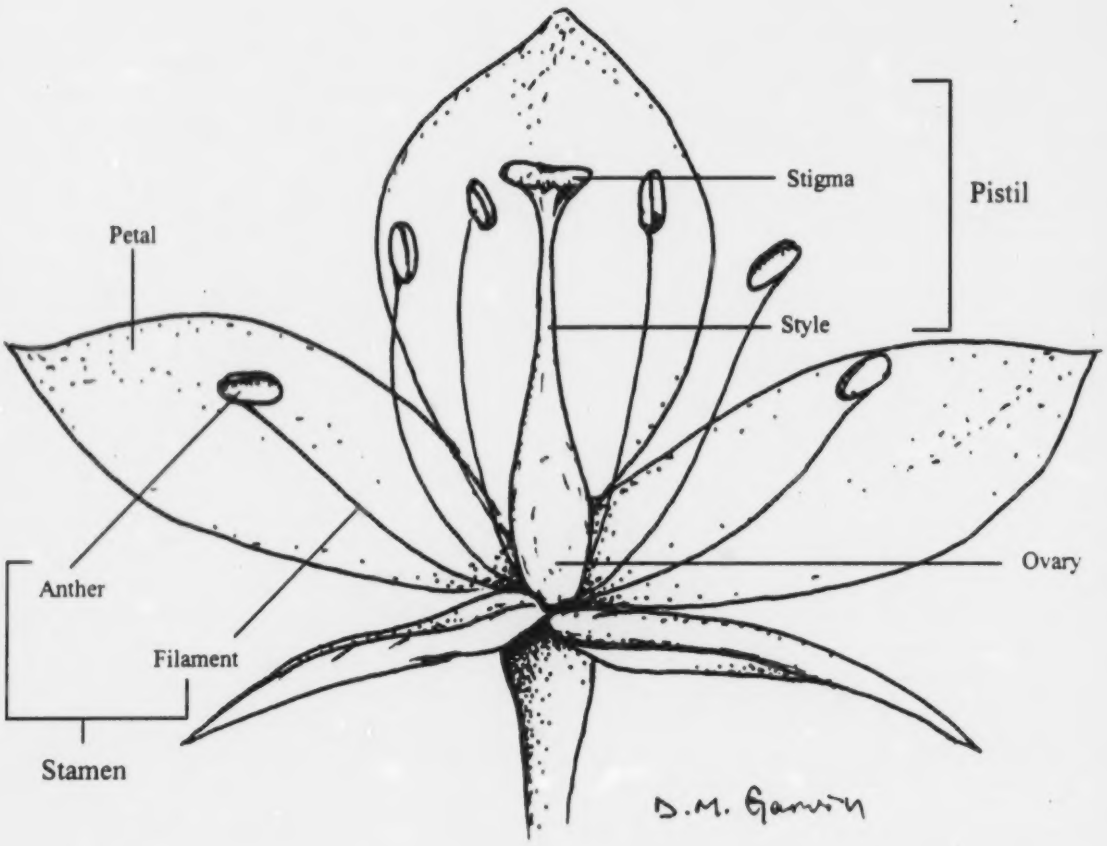
_____

_____

4. Draw on the other side of this sheet, at least two insects you saw at your flower.

Information Sheet

Perfect Flower



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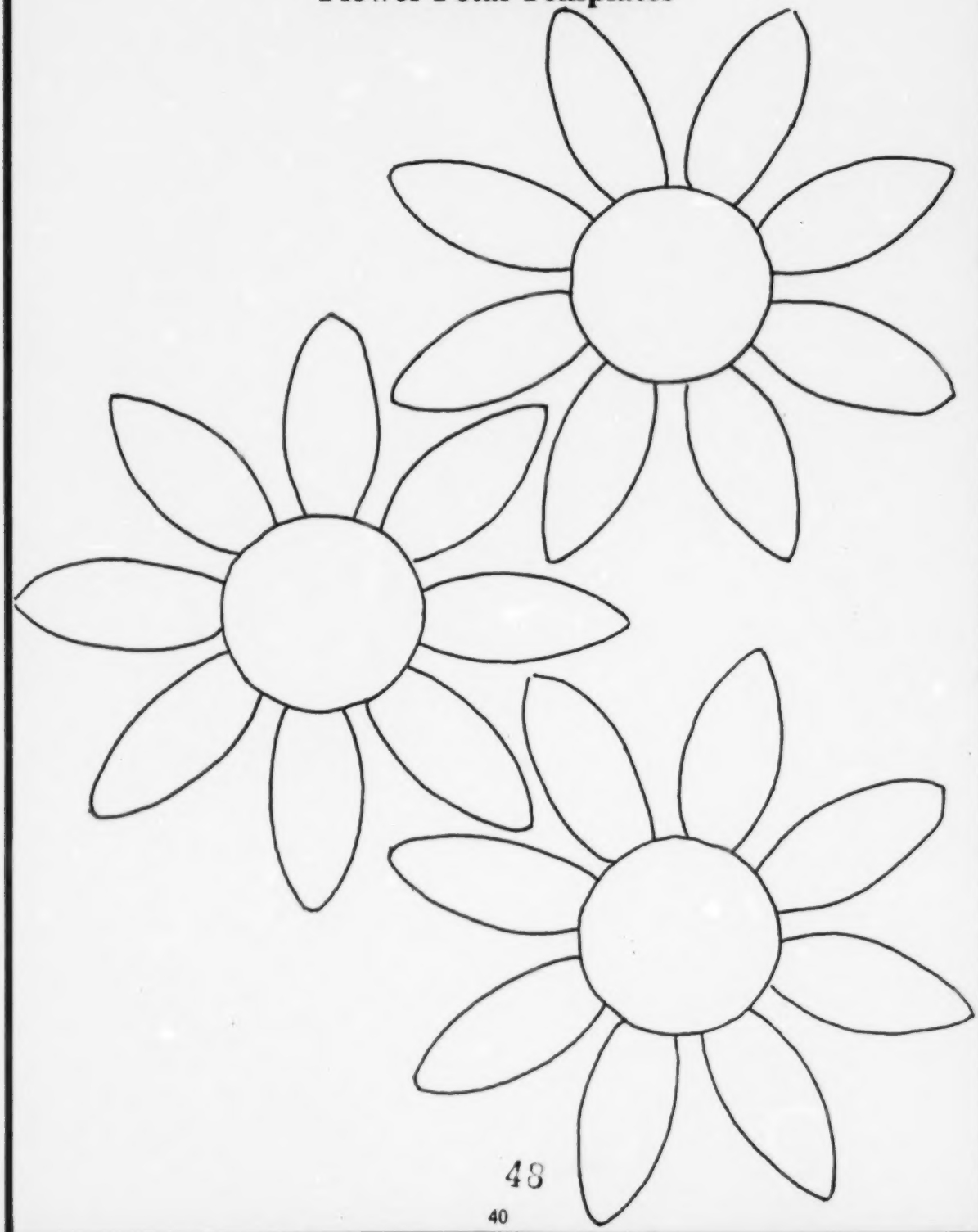
Template for Nectaries

Flower Petal Templates



Seed Dispersal

I Get Around

GRADE LEVEL/TOPIC: 4-6/Plants

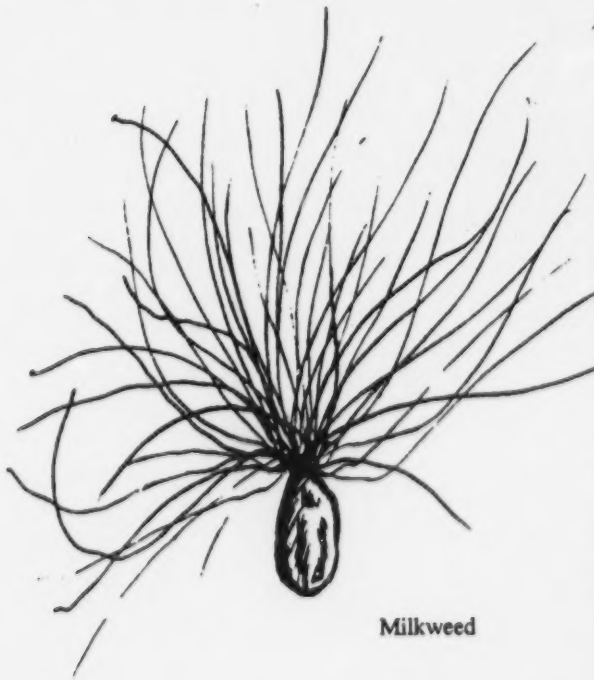
TIME REQUIRED/RECOMMENDED SEASON: 90 minutes/Spring

SCIENCE SKILLS: Observing, Data Collecting and Recording, Identifying, Model Building

KEY WORDS: Fruit, Seeds, Dispersal, Scat, Pollen

OVERVIEW

This Activity begins with building a working model of a wind-dispersed seed (30 minutes). The students will also make and install traps to collect pollen and other wind-borne particulates (30 minutes) and return after several hours or a day to check on them (30 minutes). Feel free to divide this lesson into several smaller lessons. If this is your first Activity, please consult the Introduction.



Milkweed

PURPOSE

1. Students will identify ways in which seeds are dispersed in nature, including self-propelled, wind, water, birds and mammals.

2. Students will conduct an experiment which will allow them to observe wind-borne pollen and seeds and other particles.

MATERIALS

For Class

- Examples of maple seeds
- Template sheet for maple seed helicopters
- White paper on which to photocopy template sheet (heavy paper works best, but copy paper is fine)
- Petroleum jelly
- Plastic spoon

For Each Student

- Photocopied maple seed helicopter template
- Scissors
- Crayons
- Paper clip
- Sheet of construction paper
- Clipboard and pencil
- Sheet of white drawing paper
- Thumbtack
- Piece of scrap paper, folded several times, to spread petroleum jelly

Prepwork

Gather examples of seeds from nature to show your class. Examples could include maple helicopters, cottonwood fluff, puts, grass seed, dandelions, etc. Photocopy the template of the maple seed helicopter onto heavy drawing paper to produce one helicopter for each student. Cut individual helicopters apart.

BACKGROUND INFORMATION

In order to survive, plants must produce viable **seeds**, or offspring, and **disperse**, or spread, their offspring to locations where they will not need to compete with their parents for sunlight, soil, water and nutrients. For more information on seed and fruit production, see the Pollination Activity for grades 4-6.

Because plants cannot move, they grow specialized seed containers and/or fruits which employ a variety of methods of dispersal by utilizing outside influences. The wind carries the seeds of plants which have developed cotton-

like parachutes (ex. Dandelions) or winged fruit (ex. Maple trees) to more suitable sites. The fluffy parachutes on the seeds of the Eastern Cottonwood tree enable the seeds to travel long distances through the air. An additional avenue of dispersal comes from their ability to float on the surface of nearby bodies of water.

Many plants depend on animals to aid them in dispersing their seeds. Burdocks and Beggar Ticks have seeds with hooks or barbs which attach to the fur or clothing of mammals passing by and "hitch" a ride to a new location. (This method of dispersal inspired the creator of Velcro.) Duckweed seeds travel from pond to pond on the feet of migrating waterfowl.

Because many seeds are contained in ripened ovaries, or **fruits**, which serve as food for a variety animals, their storage and consumption often lead to seed dispersal. Squirrels store nuts such as acorns, Hickory nuts and Walnuts in the ground and often fail to return for them. The seeds of Raspberries, Mulberries and Cherries pass through the digestive tracts of mammals and birds intact and are deposited in their droppings, or **scat**. For this reason, seeds are often concentrated in areas which are frequented by the animals that disperse them: beneath power lines, in fence rows and along water.

Some plants such as Witchhazel and Impatiens have self-propelled seeds which are shot from their fruits as they dry and literally burst at the seams. Jewelweed is nicknamed "touch-me-not" because when touched by a passerby, its ripened seed pod splits open, expelling the seed.

With so many seeds on the move, it seems odd that the new plants which result from successful dispersal are so rarely observed. With the exception of young maple trees growing in the eavestroughs of buildings, the urban environment does little to nurture new plants, many of which are cut down when lawns are mowed. Natural areas like the Land Lab allow things to grow. Therefore, the Land Lab offers a distinct advantage in observing new plants and how they are distributed.

BEFORE YOU GO

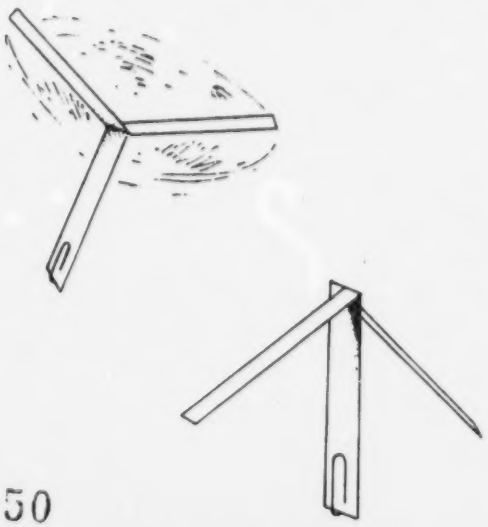
1. Introduce the topic of seed dispersal by showing your students examples of seeds which you were able to collect. Discuss how those seeds are dispersed in nature (i.e.. wind, water, animals). Also, explain to students that is important that seeds be dispersed. Seeds that fall too close to their parents do not thrive.

2. One method of seed dispersal is by the wind. As an introduction to the mechanics of wind dispersal, have the students construct a simple model of a maple seed. See illustration.

(a) Distribute an individual helicopter, scissors, crayons and a paper clip to each student.
(b) Allow the students to cut out the model and cut apart the wing flaps along the dotted line. Have them color their models if desired.
(c) Have each student attach a paper clip to the bottom of the model to represent the seed and to provide the weight necessary to achieve the desired spin. Have each student bend the wing flaps down in opposing directions.

3. Encourage each student to experiment with seed dispersal by holding the helicopter by the paper clip and throwing it up and away from himself or herself. If available, use a ladder or other steady platform to simulate dispersal from a height and a fan to simulate dispersal with wind. Have students drop seeds down the stairwells, if this is applicable to your school. Compare the flight of the model with that of an actual maple seed "helicopter".

4. To help the students observe the variety of wind-borne seeds, have them make simple traps. These traps will also collect air-borne particulates, making this a good opportunity for the students to see what is floating around in the air.

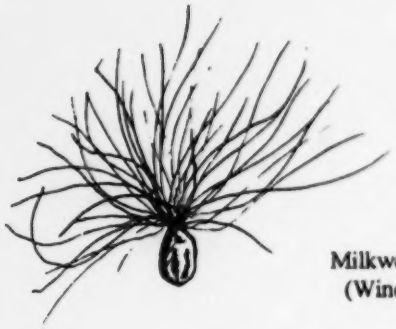


Maple Seed Helicopter Model

Information Sheet

Common Plants which Disperse Seeds

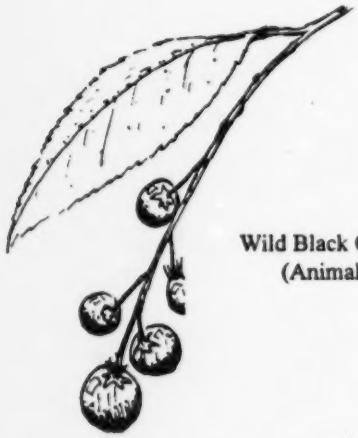
Acorn
(Animals)



Milkweed
(Wind)

Witchhazel
(Self-propelled)

Burdock
(Animals)



Wild Black Cherry
(Animals)

Bird Dropping
(Wild Black Cherry)

(a) Have each student select a piece of colored construction paper based on how they think that color will make the particulates show up. Distribute a tablespoon of petroleum jelly and a clipboard to each student.
(b) Folding the scrap piece of paper in half a few times to make a scraper, have the students spread the jelly evenly over the entire surface of one side of their papers. Students should then place their traps on their clipboards to facilitate carrying.

5. Take a box of thumbtacks outside with you to secure the traps.

PROCEDURE

1. Gather the class near the Land Lab entrance and discuss possible locations for setting the traps. Possibilities include fenceposts and rails, trees, the ground, etc. Point out what direction the wind is coming from that day and instruct your students to include this information when they make their decision.

2. Pass out thumbtacks to those students who need them. Allow the students to set their traps. Meet at a central location.

3. Orient the students again to seed/fruit production and dispersal and lead them on a guided walk to explore the Land Lab. Allow for time to explore. Encourage them to observe all the seeds encountered in the air, on the ground and on plants. For each type of seed gathered, discuss how it might be dispersed.

4. Return to the classroom.

5. Go to the Land Lab to check the traps after at least four hours have passed. If there is no rain in the weather forecast, the traps can sit overnight. Instruct students to collect the petroleum jelly traps and return to the classroom.

CONCLUSION

1. Provide each student with a blank sheet of white paper and a pencil. Allow the students to make large-scale drawings of each different particle trapped and to label whatever they can (ex. seeds, pollen, dirt, soot, insects, leaves). Optional: View interesting-looking particles under a dissecting or light microscope.

2. Have students compare their traps with those of other students. Do certain colors of construction paper allow wind-borne particulates to show up? Did certain locations collect more particulates than others? How much "man-made" material stuck to the trap? Can the students speculate on how the results of this experiment might differ if the traps were placed outside the Land Lab on cut grass or a sidewalk?

3. Can students think of hazards that seeds face when dispersing? For example, do seeds that land in a parking lot stand a chance of germinating? Also, do any animals eat seeds? If a seed landed in a really dry place, would it be able to survive? Because of these and other hazards, trees usually make hundreds or thousands of seeds. Can the students think of any animals that share a similar strategy? (Many invertebrates, fish, some reptiles and some rodents have many offspring.)

JOURNAL QUESTIONS

Tape your Maple Seed Helicopter model inside your Journal.
Write a list of the items caught in your trap and put it in your Journal.
Put at least one of your drawings from Step #1 in the Conclusion into your Journal.

EXTENSIONS

1. **Design-A-Seed**. Have small groups of students design and demonstrate seeds with a means of dispersal from a collection of materials which you provide (ex. construction paper, paper clips, rubber bands, pipe cleaners, string or yarn, pompoms, etc.). Be sure to designate one of the materials to represent the seed itself. Consider giving awards in several categories: Longest Distance, Fastest, Most Graceful, Most Realistic.

2. **Design-A-Trap**. Repeat Extension #1 but this time focus on the ultimate seed trap. Discuss with your class the kinds of traps necessary based on the mode of dispersal used by the seed. Brainstorm, allowing the class to freely offer thoughts on materials and designs. Record these thoughts on the chalkboard and decide what items would be possible to get. The following day, provide the materials identified by the students at a central location and divide the class into groups of 4-5. Allow 20-30 minutes for each group to create their own unique trap. Have each group present their invention to the class emphasizing materials used, what it is designed to trap (i.e.. wind-borne

seeds, seeds carried by water, seeds with hooks, etc.) and where it should be placed. Set traps in the Land Lab, if desired.

3. **Plant and Perch.** Mulberry trees and raspberry and grape vines are often planted from seeds in bird droppings. There are several ways to study this phenomenon. The students can set up mulch beds beneath bird roosts and monitor the beds for new plants. You or your class can string clothesline and monitor the changes in plants. Or, build and install a perching post made from scrap wood. Count, draw or otherwise monitor the plants in the autumn and/or the spring.

3. **Scat Search.** Encourage the students to watch for and carefully observe bird and mammal scat found in the vicinity of the Land Lab. Do they observe any evidence of seed dispersal?

REFERENCES/ADDITIONAL READING

Brown, Lauren. 1976. Weeds in Winter. W. W. Norton and Company, Inc. New York. 186 pp.

Burnie, David. 1991. How Nature Works. The Reader's Digest Association, Inc. Pleasantville, New York. pp. 50-51. (TLCPL)

Embertson, Jane. 1979. Pods: Wildflowers and Weeds in Their Final Beauty. Charles Scribner's Sons. New York. 252 pp.

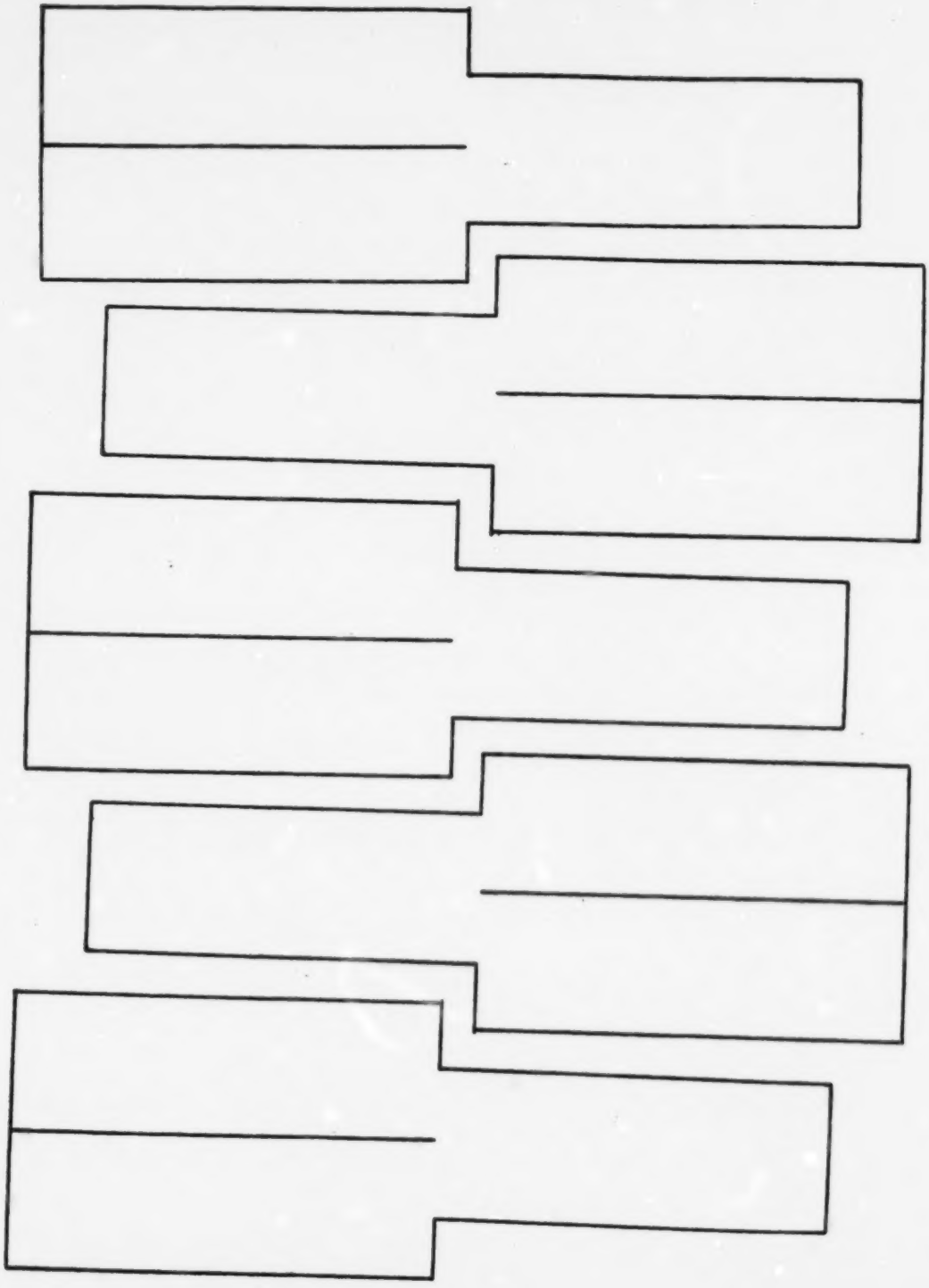
Lingelbach, Jenepher. 1986. Hands-On Nature: Information and Activities for Exploring the Environment with Children. Vermont Institute of Natural Science. Woodstock Vermont. pp. 24-25. (TLCPL)

CHILDREN'S SCIENCE/TRADE BOOKS

Rahn, Joan E. Ginny L. Winter, Illustrator. 1973. How Plants Travel. Atheneum. New York, NY. (TLCPL)
Discusses the ways in which seeds can fruits are dispersed and the advantages of dispersal, even when it fails to produce a plant.

Information Sheet

Maple Seed Helicopter Templates



Succession

One thing leads to another

GRADE LEVEL/TOPIC: 4-6/Plants

TIME REQUIRED/RECOMMENDED SEASON: 120 minutes (This can occur over several days) Spring or Early Autumn.

SCIENCE SKILLS: Observing, Monitoring, Experimental Design, Measuring, Collecting and Recording Data, Predicting

KEY WORDS: Transect, Sampling, Grass, Forbs, Trees, Succession, Frequency, Community, Biodiversity, Disturbance, Quadrat, Size Class

OVERVIEW

In this Activity, students will be introduced to the concept of sampling by conducting an experiment to sample the number of left handed students in your school (30-40 minutes). Students will then assist you in establishing a transect from which they will sample the vegetation of the Land Lab, and setting up small sampling plots at regular intervals along the transect (40-60 minutes). After learning the characteristics of the different plants the students will classify all of the vegetation in the sample plot as one of two height classes and one of three vegetation types (45-60 minutes). Feel free to break this Activity into smaller lessons executed over different days. If this is your first Activity, please consult the Introduction.

PURPOSE

1. Students will use a transect (a systematic sampling method), to sample grass, forbs and woody vegetation.

2. Students will observe changes in vegetation over time by contributing to a school-wide successional record of their Land Lab.

3. Students will construct a graph to portray the class data.

MATERIALS

For The Class

- Masking Tape

For Each Pair Of Students

- Meter or yard stick
- Marking stakes (4)
- Clipboard and pencil
- Data Sheets 1 and 2 (1 of each)

Prepwork

This Activity assumes your school has mapped the fenceposts in your Land Lab on an x-y axis. Procure enough marking stakes so that each pair has four. See the Introduction if you have not mapped the Land Lab and/or you have not made marking stakes. Photocopy one or each Data Sheet for each pair of students. This Activity assumes you will be dividing your class into pairs. If you cannot gather enough materials, you can divide your class into small groups.

BACKGROUND INFORMATION

The assemblage of plants and animals in a given area is called a **community**. **Succession** is defined as the change in plant or animal communities in an area, over time. It involves a gradual and continuous replacement of one kind of plant and animal by another until the community itself is replaced by another that is more complex (Smith, 1974).

Plant Succession

Early successional communities are characterized by having relatively few species (i.e. low **biodiversity**) and low biomass. Biomass is the weight of the living things in the community. Over time, more species of plants and animals coming into an area results in a more stable community. Stable communities have a high biomass and are able to withstand a disturbance to part of their food chain without being seriously affected. Disturbances are usually in the form of large numbers of one species dying off.

Examples of succession include the change from a field to a forest, or from a pond to a wet meadow to a forest. As you might expect, people do a lot of things to slow down or change the process of succession. In our region, prescribed burns are sometimes used to simulate the natural fires that historically shaped the plant and animal communities found in the oak forests and savannas of this area. Even the simple act of mowing your lawn at home changes the process of succession by not allowing larger plants such as trees to become established. Your school can choose to interrupt the process of succession in the Land Lab, depending on how you want it to look.

Your Land Lab is undergoing succession right now. When it was first fenced, it contained primarily grasses, plus some transplanted trees. Over time, if left alone, there will be more and more trees and more species of plants and animals.

Knowing what types of plants are present in the Land Lab can give us information about how fast succession is proceeding. This can aid in decisions about what the Land Lab will look like and how to manage it. One way to know about the plants in the Land Lab is to count them all - a daunting proposition. Statistically speaking, only some of the plants need to be counted to make generalizations about the larger population (Begon et al. 1986 p. 130). This smaller group of plants is called a **sample**.

One method of collecting the sample is called a **transect** study, or simply, sampling. A transect is a line between two points from which data are taken at regular intervals (Cooperrider et al., 1986). Each group will collect data which can be pooled (added together) to make even more accurate generalizations about the plants in the Land Lab.

The identification of these plants is not important. The kinds of plants are. The kinds of plants that can be found in your Land Lab are **grasses**, which have long thin leaves and small, inconspicuous flowers, **forbs** which have more showy flowers ("wildflowers" or "weeds") and **trees**, which have a woody stem, and are young trees or shrubs.

BEFORE YOU GO

The following Activity is a demonstration of the accuracy of sampling and starts with a question. When scientists want to find out something, they ask a question to which an experiment can provide the answer. The question is, "What is the percentage of left-handed students in your school?". Your class will arrive at the answer to this question using two methods, by taking a sample and by counting the entire population (i.e. the student body). The answers arrived at by both methods should be the same, about 10-15%. Similarly, if we want to ask, "What kinds of plants are in the Land Lab and what are their heights?" we need only take a sample to arrive at a scientifically sound conclusion.

1. Using Data Sheet 1, have your class determine the total number of students in your class and the percentage of those who are left-handed. Repeat this process for your entire grade level. Total the result of all classes in your grade level.

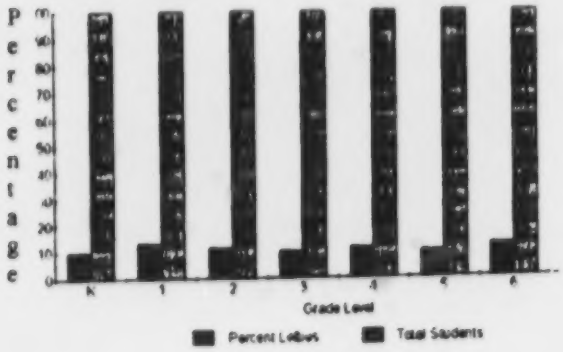
2. Divide the number of left-handed students by the total number of students and multiply by 100. This is the percentage of left-handed people in your grade level. The number of students in your grade level represents a sample of the whole school population. In other words, we can assume the percentage (about 10-15%) of students in your grade who are left-handed is equal to the percentage of students in the whole school that are left-handed.

3. To check this, repeat this procedure for grades K-6, counting the students who are left-handed and the total number of students classroom by classroom. Students can be divided into small groups and visit each classroom to accomplish this, or an announcement can be made and other teachers can send the information to the office. Use Data Sheet 1 to compile this information.

4. Make a frequency bar graph to show the results (see page 49). The x (horizontal) axis, list the seven grade levels (K-6). Along the y (vertical) axis, list the percentage of total students for each grade (always 100) and the percentage of left-handed students (around 10-15%). Using percentages makes comparable grades with unequal numbers of students.

These results show that your class could have gotten the answer to the original question, "What percentage of students in our school is left-handed?" by just sampling the classes in your grade. It is not necessary to count all of the students to arrive at the answer, although counting just one class would be too few.

Percentage of Left Handed Students



What can we learn from this in terms of the plants in the Land Lab? We can infer that by sampling a part of the population of plants, we do not need to count every plant in the Land Lab.

5. Introduce the different kinds of plants to be sampled in this Activity. If desired, show students pictures of a forb (such as a Dandelion), a grass and a tree.

6. Discuss the kinds of data to be collected. Students will be using the marking stakes to establish a 25 cm X 25 cm sampling plot, or quadrat. Working in pairs or small groups, the students will sample all the plants within the quadrat and collect the following kinds of data:

a. The number of plants of each type in the quadrat. This involves being at ground-level and using their hands to count the number of individual plants.

b. The height of each plant in the quadrat. The students will indicate on Data Sheet 2, each plant as belonging to one of two size classes. That is, all plants will be either 0-0.5 meters tall, or taller than 0.5 meters. This makes exact measuring unnecessary, yet provides valuable information about the height of the plants.

7. Make sure all of your students can use a meter stick by measuring the height of objects inside. Give each pair of students two pieces of masking tape to put at the 25 cm and the 0.5 meter (50 cm) marks. This will aid in determining measurements in the field.

8. Give each pair four marking stakes, a clipboard and pencil, Data Sheet 2, and the meter stick. Take the class outside.

PROCEDURE

1. Once in the Land Lab, review each plant type. Forbs and trees will be the easiest to count, but grasses will be the most numerous.

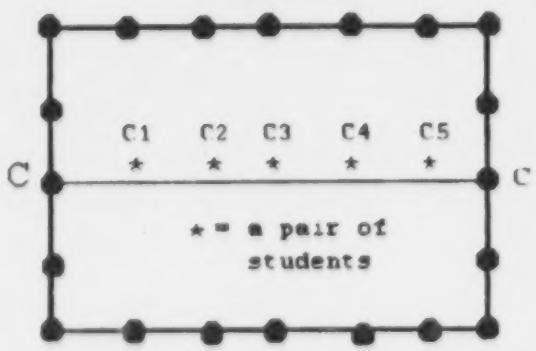
2. Show students what constitutes one plant by separating the blades of grass down by the base of the plant until you can see one stem. When you are sure you have one plant, ask a student to measure and place it into one of the two size classes.

3. Choose a fencepost to start from that has a corresponding fencepost on the other side of the Land Lab. Have you and your students picture an imaginary line running from fencepost to fencepost. This line is from C to C on the illustration, below.

4. Have the pairs of students spread out along this imaginary line. They do not have to stretch all the way.

5. Have each pair visually position themselves so that they stand at the intersection of a fencepost and the imaginary line. The fencepost will give them a point of reference, should they need to find their post again. Students should record the fencepost number and letter, the intersection of which is their starting point. See illustration below.

Your Land Lab



6. In order to randomly place their quadrats, instruct the pairs to do the following. Holding a marking stake in one hand, one student should walk three steps toward one of the fenceposts, stop, bend over, and push the stake into the ground. This will be the bottom right corner of the quadrat. Using the meter stick and the rest of the marking stakes, have each pair mark the other three corners of their quadrat.

7. Have each pair decide who will collect data first and who will count and measure plants. Instruct pairs to begin collecting data and to switch roles when about half of the plants are counted. Record information on Data Sheet 2.

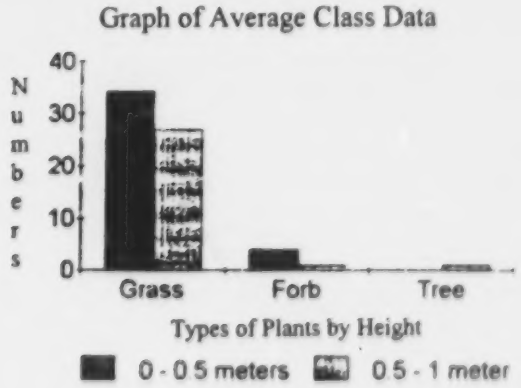
CONCLUSION

1. Have each pair of students add up their tally marks such that they get six "total" numbers.

2. Make space on the board such that each pair can write their "total" numbers in the correct category. Have students add together the numbers on the board to arrive at six Class Totals. The Class Totals should then each be divided by the number of pairs in your class, thereby averaging the data. This is called 'pooling the data', and makes the results more accurate. It is similar to using the number of left handed students from an entire grade instead of just one class.

3. Have students copy the Class Totals on the second chart on Data Sheet 2.

4. Instruct students to graph the results of the class. They should have six categories on the x axis (the kinds and heights of plants) and the number of plants on the y axis. See graph with example data on the following page.



5. What kinds of plants did the class count the most of? (If this Activity is done within the first 10 years of creating the Land Lab, there should be mostly grasses.) Do the students expect the numbers of each kind of plant to be constant over time? Ask students to predict what the number of each kind of plant would be in 10, 50 or 100 years.

6. Were most of the plants in the smaller height class or the larger? Do the students expect the numbers of plants in each height class to be constant over time? Ask students to predict how the height of the plants in the Land Lab will change over time.

7. Teachers should keep a permanent record of this exercise, and in future years compare results of their class with previous years' classes.

JOURNAL QUESTIONS

What do you think the Land Lab will look like in 10 years?
Write a story about an animal that lives in the Land Lab.
Put one of your Data Sheets in your journal.
Draw an example of each of the three kinds of plants you observed in the Land Lab.

EXTENSIONS

1. **Compare Results With Other Classes.** If other classes have done this Activity at your school in the past, compare your class' results to theirs.

2. **Play Oh Deer!** Oh Deer! in Project Wild is an active game that involves counting and graphing numbers of deer over time.

3. **It's Just Mean-Spirited.** This Activity will give you an average, or mean, number of plants found in a 25cm X 25cm piece of your Land Lab. Your class can then measure the area of the Land Lab (length X width), convert it to centimeters, and figure out the total number of plants in the entire Land Lab!

REFERENCES/ADDITIONAL READING

Begon, Michael, John L. Harper, and Colin R. Townsend. 1986. Ecology: Individuals, Populations and Communities. Sinauer Associates, Sunderland, MA. p. 130 and 539-586.

Cooperrider, Allen Y., Raymond J. Boyd, and Hanson R. Stuart, eds. 1986. Inventory and Monitoring of Wildlife Habitat. U.S. Dept. Interior, Bur. Land Management. Service Center. Denver, CO. xviii, pp. 296-305.

Minnesota Environmental Sciences Foundation. 1972. Environmental Investigations - Sampling Button Populations (Number 79098). National Wildlife Federation, Washington, D.C. 15 pp.

Smith, Robert L. 1974. Ecology and Field Biology. Harper and Row. New York, NY. 850 pp.

Western Regional Environmental Education Council. 1983. Oh Deer! Project Wild (Elementary). pp.131-134.

CHILDREN'S LITERATURE/TRADE BOOKS

Reed, Willow. 1991. Succession: From Field to Forest. The Living World Series. Enslow Publishers, Inc. Hillside, NJ. (TLCPL)
Discusses the different kinds of plant succession, the relationship between this process and people and the effect on plant communities.

Roth, Charles E. 1993. The Amateur Naturalist: Explorations and Investigations. An Amateur Science Series Book. Franklin Watts. New York, NY. (TLCPL)
Presents a variety of activities and projects to help the amateur naturalist explore the habits of common plants and animals.

Data Sheet 1

Succession

Name_____ Date _____

Sampling Left-Handed Students

1. Total number of students in your class. _____

2. Number of left-handed students in your class. _____

3. Divide the answer of #2 by the answer of #1. This is the percentage of left-handed students in your class. _____

4. Total number of students in your grade. _____

5. Number of left-handed students in your grade. _____

6. Divide the answer to #5 by the answer to #4. This is the percentage of left-handed students in your grade. _____

Repeat steps 1-3 for your whole school.

Grade	Total Cls1	Left Cls1	Total Cls2	Left Cls2	Total Cls3	Left Cls3	Workspace	Percent of Lefties
K								
1								
2								
3								
4								
5								
6								

To compare these results, graph the percentage of left-handed students in each grade at your school.

Data Sheet 2

Succession

Names_____ Date _____

_____

1. You started at the intersection of a numbered post and a lettered post in the Land Lab. Write the number and letter here.

_____

2. Place a tally mark in the proper category for each plant that you counted.

	0 - 0.5 meters	Total	0.5 - 1 meter	Total
Grass				
Forb				
Tree				

3. Add up the number of tally marks for the grasses, forbs and trees seen in the Land Lab. Put those numbers in the Total column, above.

4. Put the six Class Totals below.

	Class Total 0 - 0.5 meters	Class Total 0.5 - 1 meter
Grass		
Forb		
Tree		

5. Graph the Class Totals on the other side of this sheet.

Invertebrate Censusing

The Spineless Wonders

GRADE LEVEL/TOPIC: 4-6/Animals

TIME REQUIRED/RECOMMENDED SEASON: 60 to 90 minutes for net construction, 90 to 120 minutes for censusing on each of two days/early Autumn (before frost)

SCIENCE SKILLS: Sampling, Identifying, Censusing, Collecting and Recording Data, Graphing, Comparing, Analyzing

KEY WORDS: Transect, Sweep Net, Census, Mark and Recapture, Habitat, Population, Diversity, Invertebrates, Insects, Arachnids, Classes, Orders, Bugs, Beetles, Butterflies, Moths, Leafhoppers, Grasshoppers, Crickets, Flies, Spiders

OVERVIEW

This Activity explores the diversity and relative abundance of invertebrates in the Land Lab through sampling along a transect and marking and recapturing grasshoppers to estimate their population. It begins with the construction and demonstration of a sweep net (60-90 minutes). It continues with the sampling and censusing of all invertebrates and the marking and recapturing of grasshoppers in the Land Lab (60-90 minutes) on two days. It concludes with the graphing of the relative abundance of selected orders of insects and arachnids and the estimation of the population of grasshoppers in the Land Lab (30-45 minutes). This Activity may be divided into shorter sessions to accommodate your time allocation for science. If this is your first trip to the Land Lab, please consult the roduction.

PURPOSE

1. Students will distinguish among major orders of insects and arachnids, including bugs, beetles, flies, grasshoppers and crickets, butterflies and moths, leafhoppers, and spiders.

2. Students will build and utilize a sweep net to sample and census the invertebrates living on the grasses in the Land Lab to determine relative abundance and diversity.

3. Students will use a Mark and Recapture technique to estimate the population of grasshoppers in the Land Lab.

MATERIALS

For The Class

- Invertebrate Censusing Data Sheet master
- Groups Of Insects and Arachnids Information Sheet master
- Utility knife
- Roll of plastic wrap
- Masking tape
- Pair of pliers
- Large map of the Land Lab
- Large sheet of newsprint
- Permanent black marker
- Bottle of brightly colored nail polish
- Toothpicks (2)

For Each Group Of 2 Students

- 5-gallon plastic bucket
- 0.61 m X 0.61 m (2' X 2') piece of cardboard with plastic window
- Invertebrate Censusing Data Sheet
- Groups Of Insects And Arachnids Information Sheet
- Clipboard with pencil
- Scissors
- Glue

For Each Student

- Old light-colored pillow case
- All-wire coat hanger
- 0.6-1.2 meters (2-4 feet) of electrical or duct tape, depending on width
- Graph paper
- Ruler
- Pencil
- Crayons or markers

Prepwork

Have students bring in old light-colored pillowcases (no holes) and all-wire coat hangers from home until you have collected enough for one per student. Disassemble the wire coat hangers into long, straightened rods, using pliers if necessary. Construct a sample sweep net to show the students. Collect 5-gallon plastic buckets and large cardboard boxes until you have enough for one bucket and one 0.61 m X 0.61 m (2' X 2') piece of cardboard per every two students. Using the utility knife, cut the cardboard into square covers for the buckets. Cut a 25-cm (10") square out of the center of each cardboard cover. Cover the hole with plastic wrap, and secure the edges of the plastic with masking tape to create a window. Photocopy the Invertebrate Censusing Data Sheets and the Groups Of Insects And Arachnids Information Sheets, producing one per two students. Gather all other necessary supplies.

BACKGROUND INFORMATION

Have you ever wondered how people know that a species of animal is endangered? To make this determination, scientists had to locate the animals' specific habitats and count them. Keeping records over a long period of time enables scientists to observe trends in their **population**, or numbers, especially decline. In this Activity, your students will sample and census **invertebrates**, or animals without backbones, in the specific **habitat** provided by your Land Lab (grasses and other plants above the ground). They will use this information to examine the **diversity**, or variety, and relative abundance of insects and arachnids living there. They will also use a technique called **Mark and Recapture** to estimate the population of grasshoppers in the Land Lab.

In Mark and Recapture, all of the individuals of a species caught during one sampling period are marked and released. Insects are generally marked with nail polish or model paint, both of which adhere well to their exoskeletons. Then one to two days later, the study area is sampled again in an identical way, and the marked individuals recaptured are compared to the total number of individuals marked and the total individuals captured on the second day to estimate the total population of the animals. The proportion is as follows:

$$\frac{\text{Total Individuals Marked}}{\text{Est. Total Population (X)}} = \frac{\text{Marked Individuals Recaptured}}{\text{Total Individuals Captured (Day 2)}}$$

This method assumes that the marked animals will redistribute themselves randomly in the population and that marked and unmarked animals have an equal chance of being caught. Because the sampling is done in the same way each time, the animals caught on the second day are considered to be an accurate sample of the entire population when the marked animals are compared to the total number of animals. (Cooperrider, Boyd and Stuart, 1986)

Using a sampling method to estimate a population is an important scientific technique because counting every individual would be too difficult and time consuming. The invertebrates will be collected using **sweep nets** along **transects**, or straight lines, so that sampling may be done in the same way each time. (See the Succession Activity for grades 4-6.) Your **census**, or count, can then be used together with the data collected by students from previous and subsequent years to observe how the populations of insects and arachnids change as your Land Lab grows and changes.

Insects and arachnids are **Classes** of animals and can be further divided into groups called **Orders**. **Insects** are invertebrates with three pairs of jointed legs and three body parts: head, thorax and abdomen. Most insects have two antennae, one or two pairs of wings and simple and compound eyes. The Class Insecta includes such Orders as bugs, beetles, grasshoppers and crickets, leafhoppers, butterflies and moths, flies and bees. Bees will not be counted in this census for safety reasons, but your students should be alert to the fact that ground-nesting yellow jackets can be very aggressive in the early Autumn and should be avoided whenever possible. **Arachnids** are invertebrates with four pairs of jointed legs and two body parts: cephalothorax and abdomen. They have no antennae or wings. The Class Arachnida includes the Order Araneae, or spiders. The orders included in this study are described here for your reference:

Grasshoppers and Crickets (Order Orthoptera) - medium to large insects with chewing mouthparts, conspicuous antennae and swollen femurs (thighs) containing powerful jumping muscles. These insects use songs, called stidulations, in courtship and have the most well-developed tympanic (auditory) organs among insects. Crickets have more broad and flattened bodies than their grasshopper relatives, and some possess a pair of long, pointy, sensory appendages, called cerci, on their abdomens.

Bugs (Order Hemiptera) - insects of all sizes with piercing, sucking mouthparts, forewings which are thick and leathery near the base and membranous near the tip and a triangular plate, or scutellum, over part of the thorax. Most bugs have special stink glands as a defense against would-be attackers.

Leafhoppers (Order Homoptera) - generally small insects with uniformly membranous wings held roof-like over the body and sucking, beak-like mouthparts located near the rear of the head. Aphids also belong to this order and may be winged or non-winged.

Beetles (Order Coleoptera) - insects of all sizes with two prominent compound eyes, armor-like forewings which meet in a straight line down the middle of the back and chewing mouthparts with well-developed mandibles. Beetles constitute about one-third of all animal species with more than 300,000 species known.

Butterflies and Moths (Order Lepidoptera) - medium to large insects with two pairs of large membranous wings covered with flattened, often colorful scales and siphoning mouthparts (proboscis) coiled under the head at rest. Butterflies hold their wings together over their backs at rest and have long, slender antennae with clubbed ends. Moths spread their wings sideways at rest and generally have feathery antennae. Most moths are also nocturnal.

Flies (Order Diptera) - insects of all sizes with a single pair of membranous wings, inconspicuous antennae and sucking mouthparts adapted for sucking, sponging or lapping liquids. Flies have balancing organs, called halteres, and claws and pads on their feet, giving them great maneuverability in flight and the ability to land almost anywhere. (Imes, 1992)

Spiders (Order Araneae) - arachnids of all sizes with a generally unsegmented abdomen attached to the cephalothorax by a narrow stalk, eight simple eyes variously arranged and spinnerets near the tip of the abdomen for the production and distribution of silk. All spiders are carnivorous, and most possess poison glands containing venom to subdue their prey. (Levi, 1987)

BEFORE YOU GO

1. Discuss with your students the value of sampling and censusing to estimate the size of a population of animals or determine its diversity. Introduce the sweep net as a sampling technique.

2. Divide the students into groups of two. Have each student make a sweep net working with his or her partner.
(1) Distribute pillowcases, straightened wires, pieces of electrical tape and buckets to the students. Have the students set the bucket upside down on the floor for use as a form to shape the rim of the net.
(2) Have each student, one partner at a time, bend the straightened wire around the bucket just above the handle (towards the bottom of the bucket) and twist the leftover wire end over end until all of the wire is used up. Leaning over the bucket and twisting on the opposite side makes this process easier. You may need to assist with pliers.
(3) Have the students remove each hoop from the bucket and wrap the twisted wire with a piece of electrical tape to form a handle.
(4) While one partner holds the rim horizontally, have the other student lower the pillowcase through the hoop with its open end up and fold the top edge (along the seam, if possible) over the rim. This student can then glue the fold in place over the rim. Allow the nets to dry overnight.

3. Using the map of the Land Lab, describe to the class how the area will be covered during sampling. Assign x or y coordinates (whichever represents the shortest sampling distance) to each pair of students. Explain that one student will sweep along the transect marked by the fenceposts at their assigned coordinate, and the other will sweep back in the opposite direction along a transect between their fence posts and the fenceposts of the next group. Caution the students not to disturb other projects.

4. Demonstrate how to use the sweep net and how to empty the net at the end of each sweep. At grass level, slowly swing the net back and forth from hand to hand, turning it so that the open end always faces the direction of the swing. Stress the importance of keeping the net moving. If students must stop, it is necessary to close the

Sweep Net

net by turning the hoop perpendicular to the ground or grabbing the net just below the hoop so that the captured invertebrates do not escape. **Before emptying the net, the students should close the nets by turning the hoops perpendicular to the ground and hold the nets to their ears to listen for the buzzing sound which signals the presence of a bee.** Reopening the nets briefly will allow the bees to escape. To demonstrate emptying the net, place the hoop of the net over the mouth of the bucket and push and shake the net into the bucket. Remove the net and quickly cover the mouth of the bucket with a cardboard lid with plastic window.

5. Distribute a Groups Of Insects and Arachnids Information Sheet to each pair of students. Describe the groups of invertebrates likely to be captured in the sampling process as outlined in the background information. Explain that grasshoppers will be utilized to estimate a population, and describe the Mark and Recapture technique to be used.

6. Distribute a bucket, cardboard lid with plastic window, Data Sheet and clipboard with pencil to each pair of students. Remind the students to take these, the handouts and the nets with them into the field. You will need to take the bottle of nail polish and a toothpick.

PROCEDURE

1. Have each pair of students report to the fencepost marking their assigned coordinate. Direct one of the students from each pair to carry their bucket to the opposite fencepost and wait for his or her partner. When all are ready, have the remaining student sweep with a net along the first transect until he or she reaches the opposite side of the Land Lab. The student should quickly close the net, check for bees and empty the remaining invertebrates into the bucket as previously directed. The second student should cover the bucket and carefully tally the groups of invertebrates captured on the Data Sheet by looking through the plastic window.

2. Visit each pair of students as they complete their tally and mark all of the grasshoppers which they have collected with nail polish. Carefully hold each grasshopper by the upper joints of both hind legs (avoiding the wings) and place a tiny dab of nail polish on the plate behind the head (thorax) with a toothpick. A large dab could hinder the insect's chances of survival and adversely affect the results of your study. Return each grasshopper to the bucket for later release. **[A word about grasshoppers—Although the grasshopper cannot bite, it may secrete a dark brown juice from its mouth when alarmed. This juice is probably a defense against predators and can stain fingers and clothing.]**

3. When all grasshoppers have been marked, have the students switch roles and repeat the procedure. The students who used nets during the first sampling should carry the buckets with captured invertebrates still inside back to their original posts and move to their second transects between the fenceposts. When all are ready, have their partners sweep with nets along the new transects to the opposite side of the Land Lab. When these students have finished their sampling and closed their nets, the first group of invertebrates can be released along the transect from which they were collected. Have the students check for bees, empty their nets, cover the bucket and tally the invertebrates captured as before.

4. Mark all grasshoppers captured and instruct the students to release the second group of invertebrates along the transects. Return to the classroom.

5. On a large sheet of newsprint, compile the data collected by each of the individual teams and determine the total number of animals for each group of invertebrates collected. Have the students add this information to their Data Sheets.

6. Two days later, preferably at the same time of day, return with your class and their buckets, lids, handouts, nets, Data Sheets and clipboards with pencils and repeat the sampling Activity using the same assignments and the same order of students. It is not necessary for you to mark the grasshoppers which are captured in this sampling, but the students should be instructed to tally both marked and unmarked grasshoppers on their Data Sheets. When all students have completed the sampling Activity, return to the classroom.

7. On the sheet of newsprint, compile the data and determine the totals as before, including the marked and unmarked grasshoppers. Have the students add this new information to their Data Sheets.

CONCLUSION

1. Have the students estimate the population of grasshoppers in the Land Lab using the following proportion:

$$\frac{\text{Total Grasshoppers Marked [Day 1]}}{\text{Estimated Total Population (X)}} = \frac{\text{Marked Grasshoppers Recaptured [Day 2]}}{\text{Total Grasshoppers Captured [Day 2]}}$$

$$X = \frac{(\text{Total Grasshoppers Marked})(\text{Total Grasshoppers Captured[Day 2]})}{\text{Marked Grasshoppers Recaptured}}$$

Reemphasize the importance of sampling as a method to estimate populations of living things.

2. Have the students calculate the average number of animals captured from each group of invertebrates using the class totals from both days. For this purpose, all grasshoppers may be counted together and grouped with the crickets which belong to the same Order.

3. Distribute a sheet of graph paper to each student and instruct the students to graph the average numbers for each group of invertebrates in a bar graph format (numbers on the x axis and invertebrate groups on the y axis) to show diversity and relative abundance over the two-day period. Keep at least one student graph in the class journal or other record to observe how changes in the habitat or the season will impact the populations of these groups. Compare this year's results with previous years if other data are available.

JOURNAL QUESTIONS

Keep a copy of your graph in your journal to remind you of the diversity and relative abundance of the different groups of invertebrates. Why do you think there are so many invertebrates in habitats like your Land Lab? What is their importance?
Draw and write brief descriptions of the major groups of insects and arachnids which you observed in your census. Do you feel that the sampling technique which you used was accurate? Describe an invention or method of your own design that could more accurately sample a population of animals.

EXTENSIONS

1. **Life Goes On.** Have the students repeat the sampling Activity over a one-month period or in different seasons and graph the results to observe changes in diversity and relative abundance. Discuss possible causes of these changes.

2. **My Favorite Spineless Wonder.** Have each student choose one of the groups of invertebrates and graph its numbers over a month or a year to observe fluctuations in population. Which group or groups exhibit the greatest increase or decrease in numbers over the time period?

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Data Sheet

Invertebrate Censusing

Names _____ Date (Day 1) _____

_____ Date (Day 2) _____

Sample 1

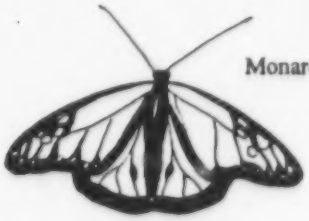
Type of Invertebrate	Tally	Total	Ave.
Grasshoppers			
Crickets			
Bugs			
Leafhoppers			
Beetles			
Butterflies/Moths			
Spiders			

Sample 2

Type of Invertebrate	Tally		Total	Aver-age
Grasshoppers	Marked	Unmarked		
Crickets				
Bugs				
Leafhoppers				
Beetles				
Butterflies/Moths				
Spiders				

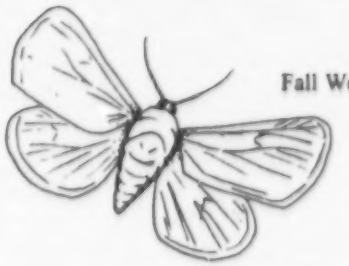
Information Sheet

Common Insects & Arachnids



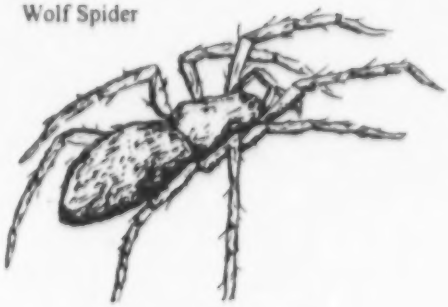
Monarch Butterfly

Grasshopper



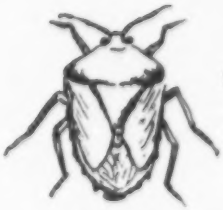
Fall Webworm

Wolf Spider



Cricket

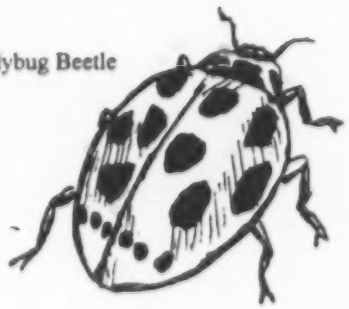
Leaf Hopper

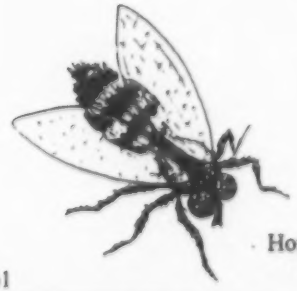


Stinkbug

Honeybee

Ladybug Beetle





House Fly

Spider Observation

Look! It's a Spider, Man!

GRADE LEVEL/TOPIC: 4-6/Animals

TIME REQUIRED/RECOMMENDED SEASON: 120 to 150 minutes/early Autumn (before frost)

SCIENCE SKILLS: Observing, Model Building, Note Taking, Record Keeping

KEY WORDS: Spider, Web (Cobweb, Funnel, Orb, Sheet), Spinnerets, Silk, Pedipalps, Fangs, Cephalothorax, Abdomen, Predator, Prey, Carnivore, Insectivore, Field Notebook, Niche

OVERVIEW

This Activity explores the feeding behavior of funnel spiders utilizing a field notebook to record observations. The students will share these observations by preparing a report and a spider model. The Activity consists of an introduction and demonstration of web function (15-30 minutes), field observation of funnel spiders and related note-taking in the Land Lab (30-45 minutes) and report writing and model building (60-90 minutes). This Activity may be divided into shorter sessions to accommodate your time allocation for science. If this is your first trip to the Land Lab, please consult the Introduction.

PURPOSE

1. Students will locate and identify funnel webs as the food trapping structure of a specific group of spiders.

2. Students will describe the food catching actions of a spider by baiting the spider with live prey and observing its behavior.

3. Students will record their observations in a field note book. They will use their observations to write a report, in letter form, about the behavior of the spider and to construct a model of a spider.

MATERIALS

For The Class

- Funnel
- Bucket
- Leg of old panty hose
- Large rubber band or heavy twine (to fit around mouth of bucket)
- Master of letter from the Ottawa Park Nature Education Center

For Each Group Of 2 Students

- 76-cm (30") piece of string or yarn
- Ruler
- Clipboard with pencil
- Sweep net (See Invertebrate Censusing Activity for grades 4-6 for instructions.)

For Each Student

- Cups from an egg carton (2 attached)
- 5 cm X 5 cm (2" X 2") squares of construction paper in earth tones - black, gray, green, brown, etc. (3-5)
- Pipe cleaners (4)
- Glue
- Scissors
- Crayons or markers
- Copy of letter from the Ottawa Park Nature Education Center
- Sheets of notebook paper (2)
- Pen or pencil

Prepwork

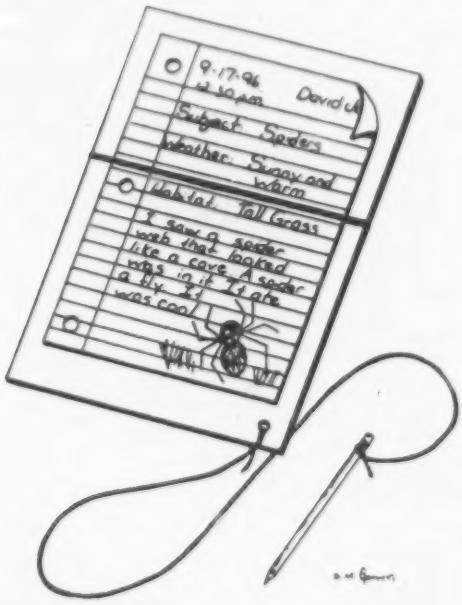
Cut one leg of an old pair of panty hose at the thigh and above the foot. Place the foot end into the bucket and stretch the thigh end over the mouth of the bucket to form a funnel. Attach the hose to the bucket with a large rubber band or heavy twine. Cut string or yarn into 76-cm (30") lengths, enough for one per two students. Have the students bring in empty egg cartons until you have enough

egg cups for at least two per student. Cut the egg cartons into strips of six egg cups. Cut the earth tone construction paper into 5 cm X 5 cm (2" X 2") squares until there are enough squares for three to five per student. Photocopy the master of the letter from the Ottawa Park Nature Education Center, making enough copies for one per student. Gather a funnel and the necessary craft supplies.

BACKGROUND INFORMATION

Spiders are among the most despised of our local wildlife. This is unfortunate because they are plentiful and, despite what we may consider bloodthirsty feeding habits, fascinating to observe. They seem undisturbed by careful observers and, therefore, afford an excellent opportunity for your students to become more understanding and accepting of them.

Spiders are arachnids, possessing two body parts and four pairs of legs. The fact that their body parts, the **cephalothorax** and the **abdomen**, are connected by a narrow stalk called a pedicel distinguishes spiders from other groups of arachnids. The cephalothorax serves as the place of attachment for four pairs of legs for walking, one pair of biting mouthparts, or chelicerae, with **fangs** for eating and one pair of leg-like **pedipalps** for manipulating prey. The abdomen is soft and sac-like and contains the organs for digestion, circulation, respiration, excretion, reproduction and silk production (Foelix, 1982).


9-17-96
Subject Spiders
Habitat Tall Grass
I saw a spider web that looked like a cave. A spider was in it. It ate a fly. It was cool.

All spiders are **carnivorous**, and their meat of choice is generally insects. An animal which eats insects is known as an **insectivore**. As **predators**, spiders have evolved different methods of obtaining their **prey**. Some, like the wandering spiders, ambush or actively pursue their prey. Many others build silk snares, or **webs**, to capture their prey. Regardless of how an insect is caught, the end result is the same. The spider paralyzes or kills the prey by injecting venom through its hollow fangs and then eats it by injecting or spitting digestive juices to liquefy the prey. It uses its stomach's pumping action to suck the prey into its mouth. If the spider cannot mash its prey into a manageable mass, it may suck out the insides of the prey and discard the outer shell, or exoskeleton (Foelix, 1982).

All spiders produce **silk** and dispense it through the spigots of three pairs of **spinnerets** located near the tip of the abdomen. The liquid silk hardens as soon as it leaves the spider's body and can then be used for a variety of purposes. Most spiders make egg sacs from silk and lay down draglines which help them escape by dropping or retracing their path. Young spiders often produce unattached draglines for ballooning, or transportation on a rising air current to a new location (Lingelbach, 1986).

Spiders which do build webs to catch insects utilize a few basic designs: **cobwebs, sheet webs, funnel webs** and **orb webs.** Cobwebs appear as irregular tangles of silk threads, like those spun by the common house spider. The sheet web is so named because the main part of the web is a flat, closely woven mat, or sheet, which is usually oriented horizontally. The beautiful orb web is oriented vertically and consists of a spiral of silk attached to a series of radiating threads which converge at a central point. The spider uses sticky, elastic silk for the spiral and dry, inelastic silk for the support threads so that it can travel across the web without becoming tangled in its own trap! (Lingelbach, 1986) The funnel web, so named because a funnel-like opening below or to the side of the web provides the spider a hiding place, will likely be a common sight in the grassy habitat of your Land Lab.

Much of what is known about the way spiders and other animals behave comes from observation and note-taking by scientists in the field. A **field notebook** is used by scientists to write a description of what they observe on the spot for more careful consideration later on. Each entry in the notebook includes such basic information as the date of the field trip, times of departure and return, temperature, weather conditions and locations and habitats visited, and observations are usually recorded as notes and drawings. For example, the following observations of a bat are excerpted from the field notes of Massachusetts naturalist Charles Roth.

BEST COPY AVAILABLE

C.E. Roth *Ithaca, NY*
April 22, 1961 *Thompson Co.*
Small skunk cabbage, marsh marigold, cattail swale in woodlot behind pond at the end of Mohawk airport runway - noon-1:00

Little brown bat (Myotis lucifugus) was hunting up and down this small marsh which is about 50 yds. long. Sky was overcast but not unduly dismal. Bat caught a variety of insects large and small. The small ones were taken in the mouth but larger ones were very obviously caught in the interfemoral membrane [the skin between its legs]. When tired the bat would hang up on a tree trunk. (Thus the positive ID) Its rest periods were short and it would begin coursing the swale again...

The information from the field notebook can later be reorganized and expanded with research in a logbook or formal report.

In this Activity, your students will organize one page of a field notebook while observing the feeding behavior of spiders. If they seem to enjoy this process, it may be a good idea to have them keep a notebook for field observations and carry it with them whenever they visit the Land Lab. Be sure to stress with your students that they should observe from a distance and that their observations do not all need to be positive. It is okay to feel negatively about what they have seen. It is important, however, to avoid imposing human values on the animals observed. The spider is not "bad" because it eats grasshoppers; eating grasshoppers is a part of its niche, its function in the habitat which it occupies. After all, grasshoppers in large numbers have been called plagues!

BEFORE YOU GO

1. Introduce spiders to your students using the background information provided. Emphasize the way in which spiders use silk to make webs for the capture of prey.

2. Explain that webs come in a variety of shapes and that the most common web found in the Land Lab is likely to be the funnel web. Demonstrate the form of this web using a funnel and the panty hose model which you prepared. Indicate that the spout of the funnel provides cover for the spider and the wide mouth provides surface area to trap prey.

3. To demonstrate the function of the web, divide the students into groups of two, and give each pair a 76-centimeter (30-inch) piece of string or yarn. Have one student close his or her eyes and wrap one end of the string around a finger while the second student holds the string taut and taps it with a pencil at different positions along the line and at different intensities. Can the "spider" detect the size or proximity of the prey? Have the students switch roles and repeat the Activity.

4. Explain to the students that they will be working in the same teams of two to observe the feeding behavior of funnel spiders in the Land Lab. Each team will locate two funnel webs and take turns baiting each web and writing and drawing observations of the spider, its web and its feeding behavior. The student who is baiting the web will need to capture an insect no more than a centimeter (half inch) in length to serve as prey for the spider.

5. Inform students that they will be using their observations to draft a letter about spider behavior and to construct a model of a spider, so it will be necessary for them to record their observations as thoroughly as possible. Give examples of the types of observations that the students will be able to make. Explain that they can make measurements using a ruler if they can do so without disturbing the spider or its web.

6. Distribute two sheets of paper, a clipboard with pencil, a ruler and a sweep net to each team of students. Review the use of a sweep net to catch insects. (See Invertebrate Censusing Activity for grades 4-6 for details.) Explain to the students that the sheets of paper represent pages from a field notebook, a tool which scientists use to write down observations about what they are studying in the field. Reinforce that the purpose of this Activity is to keep accurate field notes about the spider and its behavior. Go outside.

PROCEDURE

1. Have each team of students find a funnel web in or around the Land Lab and bait it to observe the spider's feeding behavior. Designate one student to sit with the web and to begin recording initial observations while the second student uses the sweep net to catch a prey animal. When a suitable prey has been captured, the second student should close the net and return to the web. While the first student watches, have the second student carefully place the prey on the trap portion (outer edge) of the funnel. The first student should observe and record observations about the behavior of the spider until the spider retreats from its

prey. Because this process sometimes occurs rather quickly, the students may require a few extra minutes to collect and record their thoughts after the confrontation has ended. If the spider does not attack the prey within thirty seconds or so, instruct the students to find a new web and try again.

2. As they finish, have each team locate a second web and switch roles to repeat the Activity. When all students have had an opportunity to bait the web and record observations about the spider's behavior, return to the classroom.

CONCLUSION

1. Discuss the students' observations and feelings about what they saw. Ask them what information a scientist studying spiders might want from their observations. Help them to discern emotional observations from factual ones.

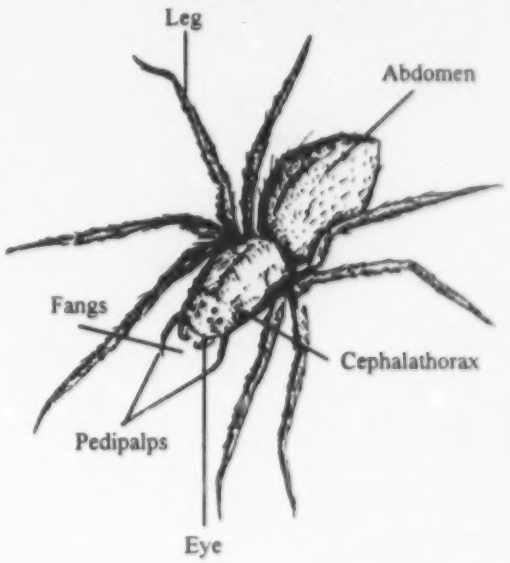
2. Pass out copies of the letter from the Ottawa Park Nature Education Center to the students. Give the students time to respond to the letter by organizing their field notes into a brief report in letter format. The letter may be written on a separate sheet of notebook paper or on the back of the letter from the Nature Education Center. Emphasize that report writing is one way that scientists utilize their field observations to educate or inform others. Include copies of the students' field notes and reports in the class journal.

3. Arrange on a centrally located table or desk strips of egg cartons (for body parts), pipe cleaners (for legs) and squares of construction paper (for facial features and markings). Include some extras of each to allow for student creativity. Distribute scissors, crayons or markers and glue to the students, and have them take turns visiting the table to select materials for their spider models. Encourage them to be creative in using the materials selected to construct accurate models of the spiders which they observed. Reinforce that like report writing, model building is a way to share observations. Have the students share their results.

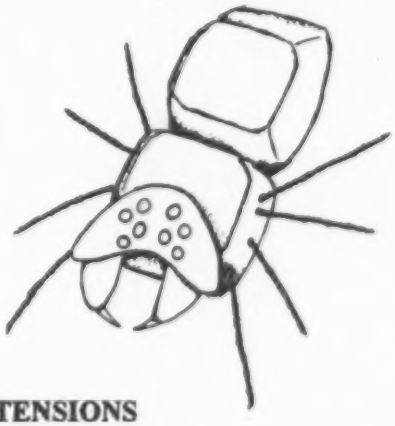
JOURNAL QUESTIONS

What types of information do you think should be included in a field notebook? Place these headings on a page in your journal and organize your field notes from this Activity as a permanent record of your spider's behavior.
If you have not yet done so, make a drawing of your spider and label its parts. Compare the drawing with the model that you constructed. Which method of recording the characteristics of the spider allowed you to be most accurate? Why?

Anatomy of a Spider



Spider Model



EXTENSIONS

1. **A Famous Confrontation**. Read the excerpt from *Charlotte's Web* by E.B. White in which Wilbur first meets his new friend. Have your students compare Charlotte and Wilbur's feelings about her with the real spiders which they observed and their own feelings.

2. **Research, Research, Research**. Scientists often prepare for and follow up field observation by researching their subject of study as completely as possible. Have your students visit a library to gather more information about funnel spiders.

3. **Is Anybody Home?** Have your students mark their webs with popsicle sticks or yarn and make several return visits over the course of a week or more. Can they observe any differences in the behavior of the spider, the remains of the prey or the web itself over time?

4. **Where Shall I Hang My Web?** Have your students locate and mark as many funnel webs as they can find in the Land Lab. Mark the location of these webs on a map of the Land Lab using the x-y coordinates. Do they observe any pattern in the arrangement of the webs within the habitat?

5. **All Kinds of Webs.** Have the students locate other types of webs, such as orb webs and sheet webs, in the Land Lab. Are they as numerous as the funnel webs previously observed? Allow the students to bait some of the webs. Do these spiders handle the business of eating any differently than the funnel spiders did?
Have the students draw and label the different kinds of webs that they observe.

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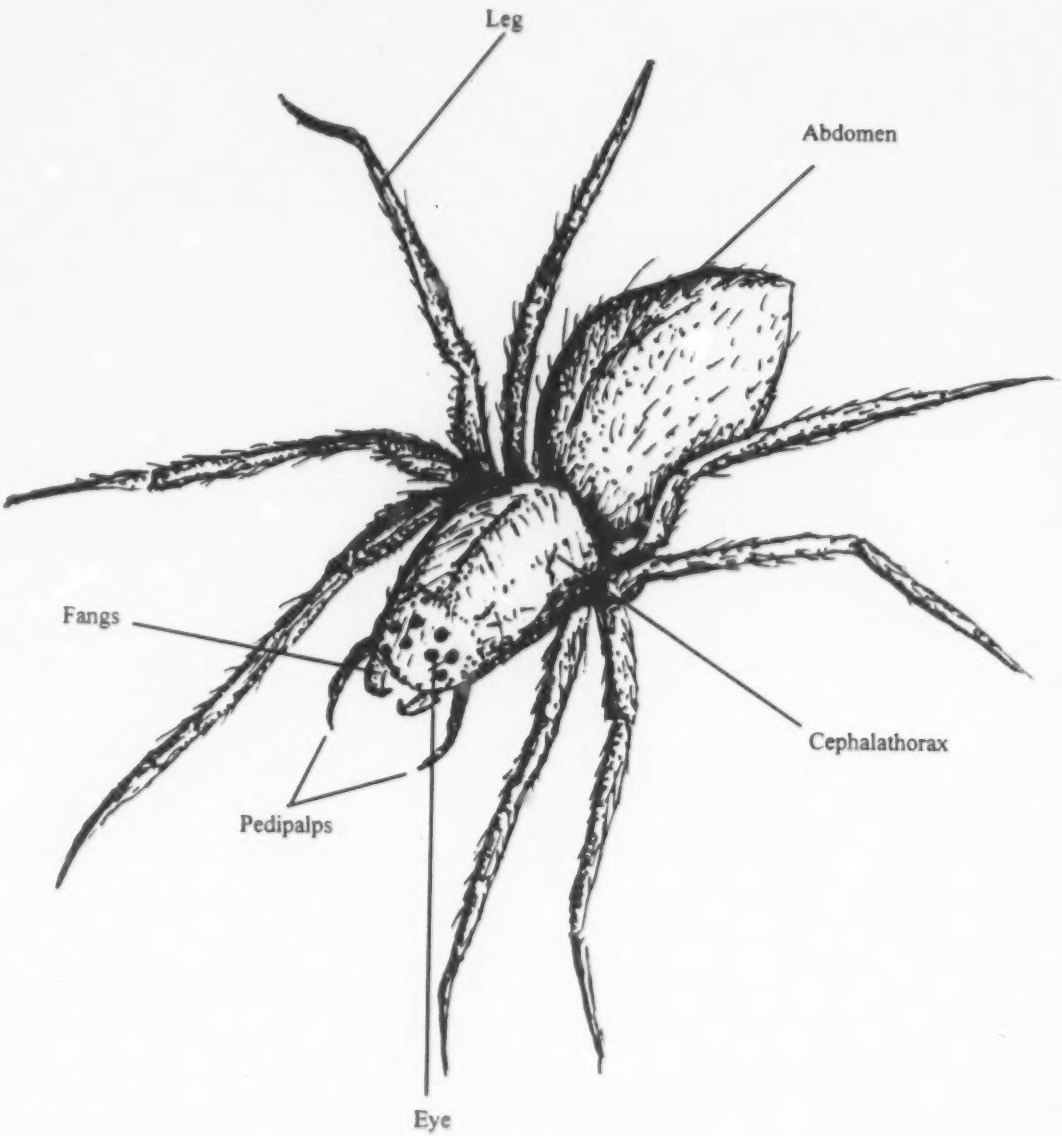
Explores physical characteristics, senses, metabolism, reproduction and growth of spiders.

Information Sheet

Anatomy of a Spider



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City of Toledo
Division of Forestry
2201 Ottawa Parkway
Toledo, Ohio 43606
January 1, 1996

Toledo Public Schools
Thurgood Marshall Administration Building
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Toledo, OH 43608

Dear Student Scientist,

The Naturalist staff of the Ottawa Park Nature Education Center is currently researching the feeding behavior of funnel spiders for a teachers' resource packet which we are planning to prepare on predators and prey. As is the case with all of the educational materials we prepare, we would like to include the most up-to-date information available on this subject. We have many valuable resources in our library on spiders but do not often have the opportunity to observe them in the field.

Therefore, we would greatly appreciate it if you could share with us any field observations which you have made regarding the feeding behavior of funnel spiders. If you have had an opportunity to observe these spiders recently, please write to us and let us know your findings.

Thank you for your time and consideration.

Respectfully yours,

The Naturalist Staff
Ottawa Park Nature Education Center

Appendix

PARK-IT!

Fourth Grade Proficiency Test
Learning Outcomes

1. Create and use categories to organize a set of objects, organisms or phenomena.
2. Select instruments to make observations and/or organize observations of an event, object or organism.
3. Identify and/or compare the mass, dimensions and volume of familiar objects in standard and/or nonstandard units.
4. Use a simple key to distinguish between objects.
5. Analyze a series of events and/or simple daily or seasonal cycles and predict the next likely occurrence in the sequence.
6. Evaluate a simple procedure to carry out an exploration.
7. Identify and/or discuss the selection of resources and tools used for exploring scientific phenomena.
8. Evaluate observations and measurements made by other persons.
9. Demonstrate an understanding of safe use of materials and/or devices in science activities.
10. Explain the operation of a simple mechanical device.
11. Identify characteristics of a simple physical change.
12. Explain and/or predict the motion of objects and/or describe the effects of some objects on other objects.
13. Make predictions about the weather from observed conditions and weather maps.
14. Identify and/or describe the relationship between human Activity and the environment.
15. Identify evidence and show examples of changes in the earth's surface.
16. Demonstrate an understanding of the basic needs of living things.
17. Identify ways in which organisms react to changing environments.
18. Distinguish between living and nonlilving things and provide justification for these distinctions.
19. Analyze and/or evaluate various nutritional plans for humans.

Sixth Grade Proficiency Test
Learning Outcomes

PARK-IT!

1. Use a simple key to classify objects, organisms and/or phenomena.

2. Identify potential hazards and/or precautions involved in scientific investigations.

3. Make inferences from observations of phenomena and/or events.

4. Identify the positive and/or negative impact of technology on human Activity.

5. Evaluate conclusions based on scientific data.

6. Recognize the advantages and/or disadvantages to the user in the operation of simple technological devices.

7. Predict the influences of the motion of some objects on other objects.

8. Propose and/or evaluate an investigation of simple physical and/or chemical changes.

9. Provide examples of transformation and/or conservation of matter and energy in simple physical systems.

10. Identify simple patterns in physical phenomena.

11. Describe simple cycles of the earth and moon.

12. Identify characteristics and/or patterns in rocks and soil.

13. Demonstrate an understanding of the cycling of resources on earth, such as carbon, nitrogen and/or water.

14. Trace the transmission of energy in a small, simple system and/or identify the roles of organisms in the energy movement in an ecosystem.

15. Compare and/or contrast the diversity of ways in which living things meet their needs.

16. Analyze behaviors and/or activities that positively or negatively influence human health.

17. Analyze the impacts of human activity on the ecosystems of the earth.

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